METAL SHOW ISSUE

Metals and Alloys

OCTOBER 1942

This Issue

WARTIME ENGINEERING ACHIEVEMENTS IN THE METAL INDUSTRIES

Metals and Alloys

THE ENGINEERING MAGAZINE OF THE METAL INDUSTRIES

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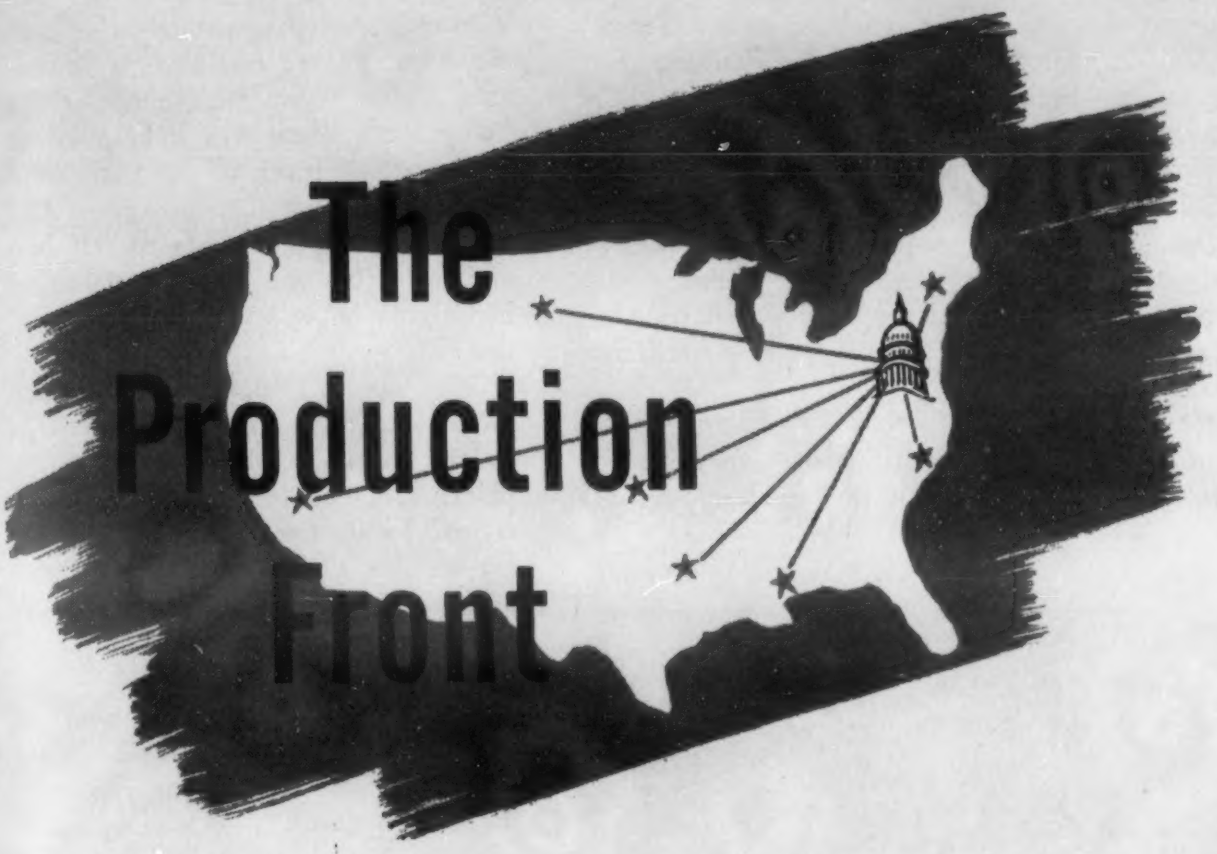
This Month—Engineering Achievements

Every Month

Metallurgical Engineering Digest

The Production Front



by Harold A. Knight
Associate Editor

Lack of manpower on heels of materials . . . We turn to womanpower . . . 75 per cent of steel goes to war . . . Statistics are censored out the window . . . Wrecked planes tell exciting metallurgical stories . . . We over-publicize substitutes . . . "The smith — a mighty man is he" is cutting up community scrap piles.

Woman wins how - to - do - it - better prize . . . Johann Schmidt is a deadened man alongside his American cousin, John Smith . . . We list some conservations of the Army . . . Masterminds give engineers stony stares . . . Many produced too fast . . . If Hitler spreads his critical materials thin, so can we.

Britain comments that others besides the U.S.A. produce astronomically . . . We get vanadium from fertilizer . . . When winter comes . . . We import scrap from Britain . . . Milwaukee pools men, machines, technicians and laboratories.

Tactics Along the Front

Emphasis seems shifted from scarcity of materials to lack of manpower—not that materials problems have been settled, however. Fighting forces of ten to thirteen millions may mean drafting of some of the fathers of the boys now in service. Married men are no longer exempt from the draft. Skilled help in war plants are no longer exempt—let the employer train green help.

The government puts on the pressure for workers to work where their services are most needed irrespective of personal convenience. About 2,300,000 Federal employees have been given notice that they may be shifted as to jobs and place of work at anytime. Men working in the critical non-ferrous metal mining, milling, smelting and refining industries have been given a "work or fight" order.

The number of women being used in war work is many times that of the World War I. Then they were emerging from the "clinging vine" era, and when any outer-panted garment like a "slack" was declasse. You and I, brother, know they have traveled far in a generation. Moreover, in a total war women get killed along with the men — so they work alongside the men to protect themselves.

Women in Greece rolled stones from the mountainside upon the advancing Germans. Women in Russia are sniping from behind trees with the guerillas. Women in the U.S.A. will do that when it becomes essential. So far, they are assembling small parts, sorting out salvaged parts, running the more pretentious machines such as lathes, ferrying airplanes and wearing military uniforms.

Many hidden talents have been revealed and many an anxious man may wonder about his peace-time job. During the first war women mostly ran elevators, buses and streetcars.

As to production, we still talk more in terms of what will be the output in 1943 rather than today, though the present is by no means to be deprecated.

75 Per Cent of Steel in War Work

Perhaps the most important measuring stick of our production over the past month was in the form of steel statistics, issued by WPB to the effect

(Continued on page 556)

that more than 75 per cent of the nation's finished steel output of 5,300,000 tons a month is now going into direct war use, and the remainder into such essential industries as railroads and machinery manufacture. This 47,700,000 tons yearly in direct war-production compares with an estimate of Walter S. Tower, Steel Institute president, one year prior to Pearl Harbor of 8,000,000 to 10,000,000 tons yearly for defense (and that, we believe, represented steel ingots, equivalent to about 7,000,000 tons of finished steel).

This is no reflection on Mr. Tower's foresight, but rather a striking illustration of the astronomical aspects of current war-production. When indirect war-production is included, it is probable that 95 per cent is going into war goods, the rest for essential civilian needs. When all this steel is turned back into ploughshares, laid end to end, they'll reach to the moon.

Figures Don't Lie, But Liars Figure

Speaking of statistics, they are virtually all "out the window" for the duration, though personally — and we hope we are not shot at sunrise as a traitor — we can't quite see the "why for." How will it help Hitler to know how much of our basic commodities we are producing? And isn't it good propaganda to tell him and bring out the cold sweat during his nights of solitude in Berchtesgaden?

We do tell percentages, which seems like an ostrich with his head in the sand. Our goal of 60,000 planes and 45,000 tanks, etc., in 1942 is world-wide knowledge. When we say we are 12 per cent (say) ahead of schedule, can't Hitler figure percentages over the base, or didn't he get that far in school?

It made a good belly laugh to see a photo of a war production plant whose caption said: "Someplace in the United States." However, unobtrusively in the background showed a sign, naming the plant and place, apparently designed for benefit of passing trains.

Metallurgical Story in Wrecked Planes

When a German airplane is shot down onto English soil, it is rushed to the metallurgists who analyze each part minutely, determine proportions of nickel (if any), tungsten, "moly," etc., and estimate how many tons of the critical metals Hitler still has. Late in September a wrecked German plane of recent make contained no nickel for the first time. We have done the same with Jap planes, and have surmised that they are by now very low on alloying materials.

As to material scarcities, the situation is much as it was a month ago, at least no worse. In some cases, too much publicity has been given to possible substitutes — like an excursion steamboat where all passengers rush over to one side to see some rowboat that has tipped over, thus overturning the steamboat. For instance, Bakelite is now scarcer than the metals for which it is a substitute.

Salvage campaigns continue apace. These are prosaic activities, for there is little glamour surrounding junk, but naturally they are vital. One of the most novel is the "Key Kollection Kampaign," conducted nationwide by the Paper & Twine Club, trade association of the paper industry. The purpose will be to collect obsolete keys of the Yale and Corbin type, which are 80 per cent nickel-silver; it is expected to yield 12,000,000 lbs.

of nickel-silver for the Navy. Proceeds from the sales will go to the U.S.O. "Key-Kans" for collections will be found where crowds gather.

Village Blacksmith Cuts Up Scrap

Missouri farmers are "mining" for junk. For years they have been filling in ditches and ravines with old, discarded pieces of farm machinery, automobile bodies, old plows, wheels — and anything else that would fill up a hole or halt erosion of their farm land.

The water wheel in a mill that ground out the first buckwheat cakes in Kansas, composed of 1,850 lbs. of metal, will now be used to grind down the Japs.

Longfellow's "Village Blacksmith" has stepped out of character and will now be found in the community scrap pile, cutting it up into charging box size. At least that is his role at Rolla, N. D.

Awards for merit from Uncle Sam are bestowed in ever-widening circles. First awards of certificates of Individual Production Merit to 16 men and one woman serving as "soldiers of production" in war plants were announced by War Production Drive headquarters early in September.

Possibly out of gallantry, the woman winner heads the list. She is Mrs. Bonnie Lee Lewis, aged 21, a former employee of the RCA Mfg. Co., Indianapolis. She suggested a motor-driven wire brush wheel for removing burrs on the molded clamping nut of a sound-powered telephone. This was previously done with a hand scraper, with considerable spoilage. The suggestion saved 2,925 man-hours.

We venture to say we have had called to our attention at least 50 ways of speeding production each month. We wonder if, when peace comes, just as much ingenuity will be expended in slowing down production.

Johann Schmidt and John Smith

To round out our talk on tactics, we must devote a word to morale-builders, slogans, propaganda and straight-from-the-shoulder talk. What we call the straight-talk-of-the-month is entitled: "John Smith (Here and Abroad) Talks About His Job." On one side is a drawing of Johann Schmidt, German. Below, Johann tells us a little about himself. He concludes: "The responsibility of winning or losing the war is not mine. I can do — I *must do* — only as I am told to do. I have no choice."

On the facing page is depicted John Smith, American, whose face is fresher, with no furrows from worry and under-nutrition. He concludes: "To sum up, no one is forcing me to help win this war. It's up to me. But if I wasn't doing my part I'd feel like a first-class heel. The responsibility rests *on me alone.*" *(General Electric Commentator)*

Army Welcomes Conservation Ideas

The Army, Navy, and Maritime Commission are taking hold of conservation with vigor. Army Ordnance, for example, with the aid of a group of officers and civilians of the "it-can-be-done" school, is displaying a showing of *how* it is being done.

Thus, scores of design changes on the standard Army rifle have reduced its weight by about 6 lbs., cut man-hour time appreciably, and reduced

costs by a substantial number of dollars. Scores of parts are stampings now, instead of machined forgings. Other parts have been redesigned to reduce weight, scrap, and man-hours.

A simple stamping now forms a bomb lug. Formerly, it was made from a forging by a number of machine operations. In a lot of 100,000, 17,000 lbs. of steel and 8,000 machine tool-hours were saved.

Nearly nine carloads of steel were saved by using a stamped clip instead of a wingnut and washer assembly for crate locks on one ordnance contract. Clips can be made 150 times as fast as the previous fastener.

Army Ordnance will save 23,353,000 lbs. of brass in 1943 for its projected program of primer cases, formerly machined from brass bar stock. Now three pressed steel parts are being used.

These are only a few of the "tremendous trifles" being publicized by the Army to industry. And Army Ordnance, in the person of Major-General T. J. Hayes, chief, Industrial Division, Pentagon Building, Washington, is looking for more conservation and substitution suggestions from industry.

"Policy Men" and Engineers of WPB

Confidentially, many technical men of WPB and other war agencies were delighted that Frederick I. Libbey "sounded off" to reporters by reading to them excerpts of a WPB inter-office memo. Despite the fact that industrialists who work with WPB know that few of the top policy men have any grasp of armament production, normal politeness has prevented the disclosure from officialdom. In Washington the gulf between most of the policy and the technically-trained men is as wide as the Potomac — and as placid. Mr. Libbey tossed a disturbing rock.

Many nationally - known metallurgists and engineers, who for as long as two years in some cases have been working hard and late on the war effort, are nearly completely "insulated" from policy levels. Their reports are read by men who either can't or won't understand, and no action is taken.

Ernest Kanzler, the new director of industry operations of WPB, knows and understands engineers — production engineers. He is in a key position to see that armament production will be *engineered* to success and not inflated with theories and hopes. Although educated in the law, he had been vice president in charge of production of the Ford Motor Co. before entering banking. He had been with WPB since February, first as chief of the Automotive Branch, and then as chief of the regional office of WPB.

Damned If They Do— Damned If They Don't!

Millions of dollars worth of war contracts are being canceled and many more will be, the basic reason being shortage of materials. The immediate reason is the dislocation of production — "imbalance," as Donald M. Nelson, WPB chairman, called it. With materials capacities far in excess of that of the Axis, we are taking a beating in production which we, as a nation, know more about than any country in the world.

Some war items, such as machine guns, cannon, rifles, trucks and specialized vehicles, and ammunition,

lend themselves to our mass-production techniques. In manufacturing other items, such as ships and airplanes, our manufacturers have adopted mass production techniques. In almost every case, it didn't take American industry long to get going when they got firm contracts, and when the design of the item contracted for was "frozen." But what did happen was that in most cases American industry underestimated its speed of production. Now what is happening?

Some of the very government spokesmen who doubted the patriotism of American business management — and said so at the beginning of the war effort — are actually blaming the speed of production, rather than a lack of overall government planning, upon those same business managements for having estimated their potential armament production too low.

"They're 'chewing up' material too fast," two of them complained to METALS AND ALLOYS, explaining the materials shortage a few days ago.

Are Our Ersatz Materials Failing?

We have been told by a trade journal editor, though haven't heard yet from first hand, that some of our emergency steels and metals are breaking down in service, the Army intimating that the steels were too stingy with critical metals alloyed therein.

But of course it may require months or years to test the "NE" steels and other makeshift metal combinations conclusively. The breakdowns we have heard rumored may be due to lack of skill in making or applying them, or total unfitness for the parts to which applied. They will not be condemned in a blanket manner, of course, at least not yet.

When Hitler first drove his panzer divisions into Austria, the newspaper correspondents laughed at the many breakdowns because of the ersatz materials used in the tanks, guns and movable units. They painted it a musical comedy invasion.

Unfortunately for the rest of the world, Hitler's mechanized forces may contain fake materials, but they have accomplished all-too-good results.

If Hitler had access to our copper, nickel and other critical metals, he would again dance the stiff little dance that expressed his exuberant feelings at the fall of France.

We should be able to do very well with our alloying materials spread pretty thin. After all, our weapons and civilian goods would, ideally, be designed to last only through the duration. That would make for economical use of materials. Then, when peace comes, all equipment will be worn out. We can start from scratch, keeping labor and returned soldiers employed for many years and permitting radically new designs in things as we build up again from scratch.

Wind Out of Our Production Sails

For about a year now we have been listening quite consistently to shortwave broadcasts to the United States, beamed from London, Berlin, Rome, occasionally from Vichy, France, and Berne, Switzerland, and by accident, perhaps, from other lesser centers, such as Budapest.

What has impressed us in the British broadcasts during the past month has been a reiterating key note, to the effect that as to per capita of population, in some cases, and in

overall production, in some instances, Britain turns out more war goods than the United States.

At first we thought we sensed a bit of jealousy in these claims, yet we wonder if, rather, the motive is fear lest we become too complacent to the point of being boastful and taking the attitude that big production only on our part is sufficient.

On Aug. 26th, Oliver Lyttleton, British minister of production, broadcast: "In the first quarter of this year we produced a little less than two and a quarter times the volume of army munitions that you did on a per capita basis, and about twice the weight of combat aircraft. In the second quarter your output grew immensely, but in proportion to population, we were producing twice the weight of aircraft and one and a half times as much army munitions. In the third quarter the comparison will be less favorable to us, and that is a great source of satisfaction. To reach our present level you will need to have nearly 40,000,000 people working for the government.

"We in Britain have been under constant air attack. I have seen a factory working at 90 per cent of capacity while part of it was on fire."

Well, that is telling us! Maybe it is partly jealousy. That is only human nature. In the days of the old mountaineer feuds, Cy Gallagher would be jealous as all-get-out of his brother Pete. But when feudin' time came round and the moon was red, let the Watkins family, the other side of the mount'in, hurt one hair of Pete's head and Cy became a hell-cat, swearing extinction of the whole blankety blank Watkins clan — and he did more than swear!

Self-Sufficient in Vanadium

Extracting vanadium from fertilizers promises to make the United States self-sufficient. Normally, 50 per cent of our vanadium comes from Peru. It is necessary for toughening armor plate, automobile axles, crankshafts, etc.

It is now proposed to extract vanadium from Idaho phosphate rock, mined by Anaconda, for use in fertilizer manufacture. Production of this rock in 1939 totaled 95,451 tons, and over 385,000 lbs. of vanadium in this rock went into fertilizer. The loss is equal to 23 per cent of the vanadium imported that year.

The new process is the result of four years' research by Dr. J. Perry Morgan, Standard Oil Co. of N. J., and Dr. Arthur W. Hixson, professor of chemical engineering at Columbia University.

It is estimated that there are 5,700,000,000 tons of phosphate rock in the Idaho deposit, of which 500,000 tons are recoverable vanadium. The ores are too low in vanadium content to be recovered other than as a by-product. However, throughout the world there are few ores containing over a fraction of a per cent vanadium. The Idaho deposit constitutes one of the largest known reserves of high grade phosphate rock in the world. These ores contain 33 per cent phosphorus pentoxide and from 0.1 to 0.27 per cent vanadium.

The new extracting process: The rock is treated with sulphuric acid; phosphoric acid in solution is formed, which is evaporated until its content

is 45 per cent phosphorus pentoxide. It is heated with strong nitric acid in an oxidizing and precipitating tank, which separates the phosphoric acid from the vanadyl phosphate (precipitated).

The phosphoric acid is filtered off to be made into fertilizer, leaving the vanadyl phosphate in solid cake form. This is treated with water and live steam, the resulting solution being placed in a precipitator and ammonia gas and ammonium nitrate added. Materials are filtered, leaving a cake of ammonia vanadate. This is heated in a furnace to produce vanadium pentoxide as a solid, the marketable product, the ammonia gas being piped off for reuse.

We Must Hurdle Winter Gracefully

Mention of the coming winter brings to mind first the most powerful ally the Russians have against Germany. However, it may prove to be somewhat of an ally of the Axis, too, because it slows United States war production. Perhaps foresight on our part will minimize its effects.

First, it will hinder our scrap and recovery program. Many salvageable items will be hidden by the snow, and winter will particularly obstruct our scrap collections from rural districts.

Second, it will retard transportation of scrap, since a large share is carried in barges on inland waterways.

Winter will have an adverse effect on both materials and labor in war production. New England foundries and metal plants invariably used to lay in large stocks of pig iron and scrap in the fall, since icebound railroads were not dependable. In more recent years this situation has not been so severe, since producers and importers have stored material handy. Yet, generally, severe winter transportation handicaps will exist.

Labor, too, will be less efficient. Many will come to work numb and depressed from lack of fuel in their own homes and snow and ice on roads, accentuated because so many workers live away from accustomed dwelling places where they had learned by experience how to overcome winter obstacles.

Much material stored outdoors, such as ore, will freeze, taking more time to thaw out and handle. Much equipment will fail due to cold weather.

It is comforting, however, to realize that industry becomes less and less seasonal as the years pass. Fabricating and erecting structural steel used to be highly seasonal. Now it is only so in mild degree. Highways used to be snowbound for weeks at a time. Modern snowplows, however, prevent this.

But this winter we must use more care and forethought than ever to keep our war industry as near 100 per cent efficient as possible.

Another Peculiar Feature in Scrap

Now comes news that Great Britain will ship scrap to the United States. Carrying coals to Newcastle! Time was not long ago when Uncle Sam was virtually supplying the entire world with scrap. In eight years, ended in 1940, we exported over 20,000,000 tons of ferrous scrap, exactly half of which went to Japan. Now, every time the Japs fire shrapnel and bombs on our soldiers, out come bolts,

nuts, gears and metal parts made in Detroit, Cleveland, Pittsburgh, etc.

To us, the most bizarre feature of a bizarre business was the central scrap buying agency in Europe that for many years bought from the United States for distribution to Germany, Russia, Italy and Great Britain. The lions and lambs had united to form a scrap kitty (the combination continuing even after Germany and Britain were at war, according to a prominent scrap dealer and exporter).

Purchases of 200,000 to 500,000 tons of scrap were made at one time, the basic purpose of the combination being to benefit by wholesale prices. Thus exporters could buy up an abandoned railroad and ship the entire equipment out on one order; and, in fact, this might be only a drop in the bucket.

Much of this scrap may have passed through complete cycles by now — scrap to tanks — and wrecked tanks to scrap again. At the end of the first year of the war we made a study that indicated that 5,000,000 tons of potential scrap had been lost to the world forever, through ship sinkings in deep water. Perhaps by now the full equivalent of the 20,000,000 tons of scrap we exported in eight years will never be recovered.

But to get back to imports of scrap from England. This may be possible partly because of large quantities of semi-finished steel we shipped Britain early in lend-lease history. Much of it comes from buildings destroyed by German bombing of British cities. Probably it will come to the U. S. as ballast in returning empty ships.

For years we have been burying comparatively useless gold in Kentucky — but we have shipped out of the country in eight years the equivalent of three month's total U. S. steel production at close to 100 per cent capacity!

"Ability and Machines" —A New Idea

Ability & Machines, Inc. is the title of a co-operative organization in Milwaukee and vicinity to further the war effort. It is a voluntary association of small shops, factories and individuals to act as subcontractors and is a "corporation, not for profit."

Such an organization would appear quite unique and set a precedent for industrial war activity, it would seem from perusing their 16 page pamphlet, which is very cleverly gotten up.

From this booklet we learn that Milwaukee ranks third in furnishing the equipment to make our Army, Navy and air forces the most powerful and best equipped in the world. Members of Ability & Machines, Inc. include metal-workers, wood-workers, instrument builders and laboratory technicians.

A composite chart shows average age of workers 40.9 years; experience, 16.8 years, etc. One column lists some 30 abilities from assemblers to welders; another lists available machines.

A.& M., Inc. has more than 12,000 man hours for sale, representing 5,000 years of experience and 1,000 machines.

It all strikes us as good organization and good sales talk about the organization. If they are half as good as the impression we get from the booklet, they can have our subcontracting!

One Thing the Japs Can't Copy

By inductive reasoning (gathering information on several details to form a picture of the whole) we have come to the conclusion that Uncle Tojo and his monkey men cohorts have only 10 per cent of the war making capabilities of the U.S.A.

First, their steel capacity is under 8,000,000 tons yearly of steel ingots, or less than 10 per cent of ours. Secondly, their engineers and technical men number less than 10 per cent of those of the United States, as judged by those attending engineering schools and belonging to technical societies.

After all, the rudiments of war production are materials and trained men to work them, so we probably do not need to go farther to arrive at our 10 per cent figure.

When we said "monkey men," above, we used the term advisedly, for the Jap engineers are apparently skilled at imitation only. There apparently never was, nor ever will be, a Robert Fulton, Eli Whitney, Wilbur Wright or Thomas Edison among the whole Jap shooting match. He who merely imitates is always one step behind the procession!

A study of one of the Zero Jap fighter planes shot down at Pearl Harbor revealed the following, which were only a few of the imitations: Engine cylinders, copied from the Wright R-975-7; valve mechanism, Pratt & Whitney; generator, Eclipse type G-1; fuel pump, Romec type F-4; propeller, Hamilton standard; compass, Fairchild; gages, U. S. Gauge Co.

One of the cleverest advertisements we have seen in a long time is that of the Timken Roller Bearing Co., depicting a genuine bearing alongside an imitation Jap number, inscribed "Timke." The ad pokes considerable fun at the yellow men for forgetting to add the "N."

But there is one important department where Mr. Jap will not be able to imitate us. Let us first tell a story.

When the Japs were hauling down the American flag at Corregidor an insolent Jap officer sneered: "'Melican flag — just a stick of candy." "Yes, but candy the Japs can't lick," suggested a bewhiskered marine.

The Japs will not be able to copy our final victory over the land of the Rising Sun!

Soft Drinks and New "Nickels"

Hereafter, when a whimsical little 20-second commercial comes over the radio: "Nickel, nickel, nickel, nickel—Pepperycola (approximately) hits the spot, etc." the sponsor will refer to a different type nickel from that when the whimsy was first written in Tin Pan Alley.

He will refer to a nickel with content of 56 per cent copper, 35 per cent silver and 9 per cent manganese, instead of 25 per cent nickel and 75 per cent copper in the five cent piece that formerly bought a bottle of Pepperycola (approximately).

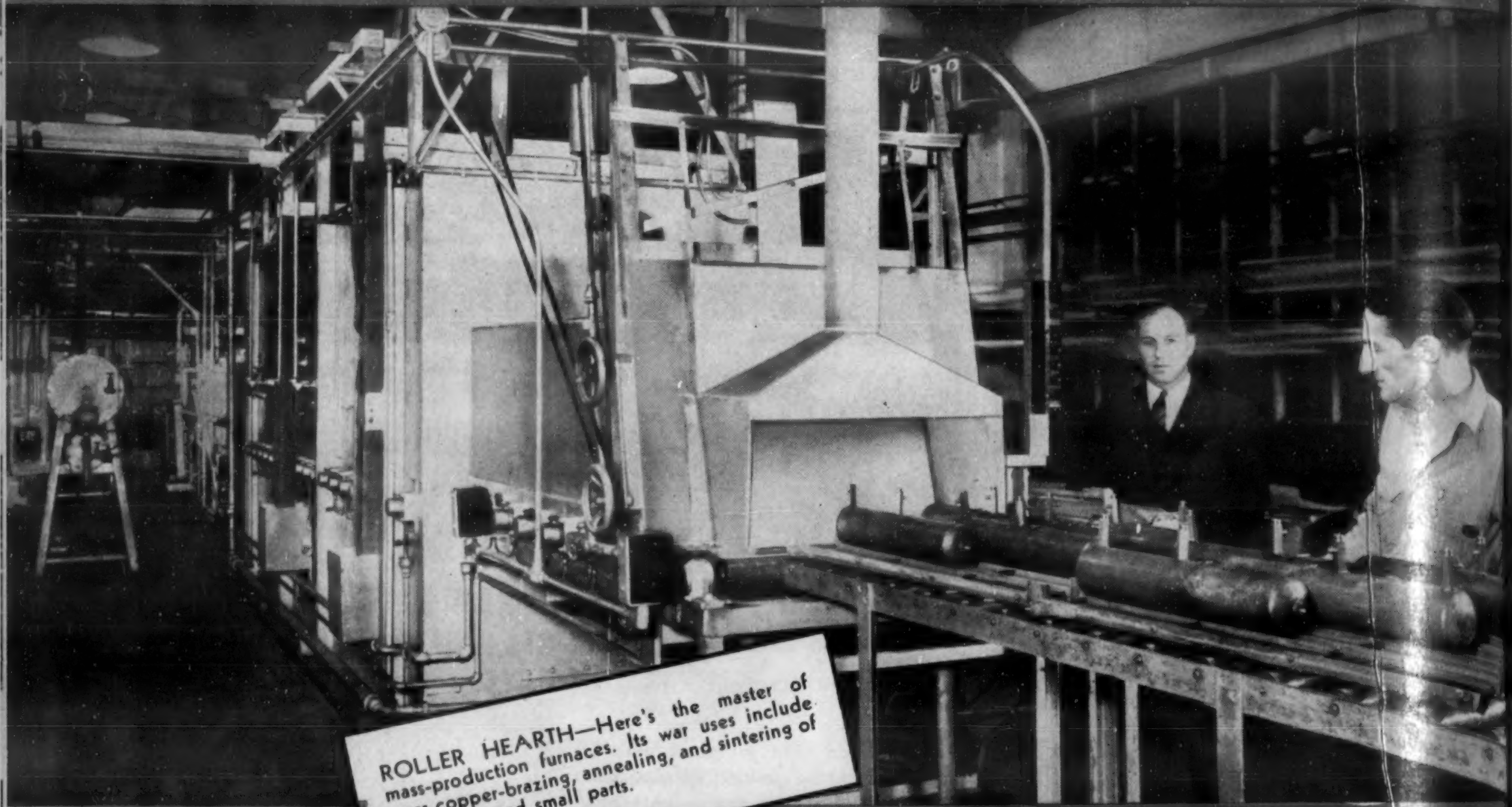
With the new "nickels," however, don't keep them in your pockets when you eat eggs or stoke the coal furnace!

Three WPB Metal Branches Merge

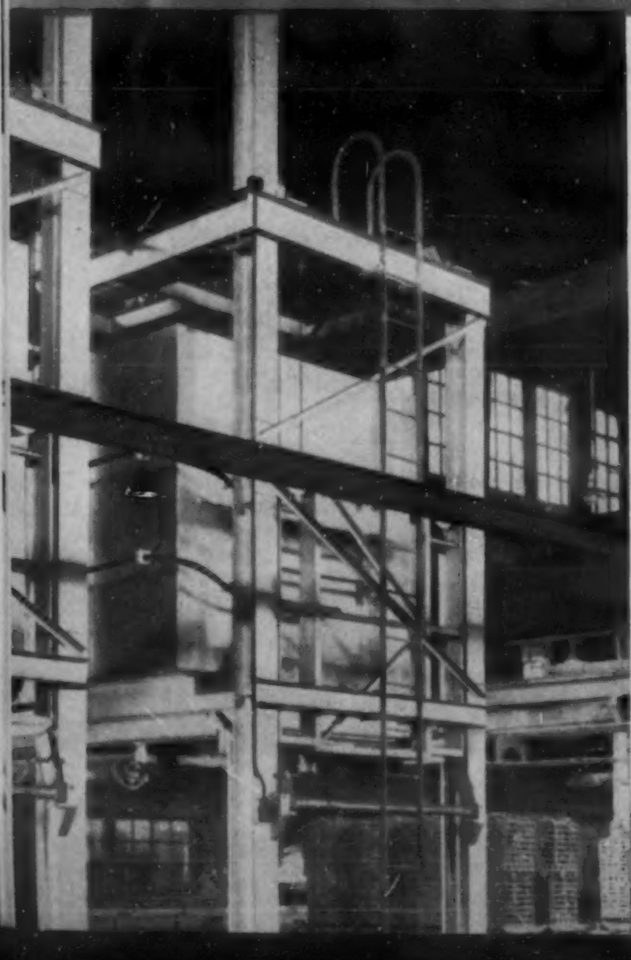
Three metals branches of WPB are being combined into one body—the Ferro-alloys Branch under Miles K. Smith, Ligonier, Pa., former head of the Tungsten Branch, which with the Nickel and Manganese-chrome branches are merged now.

Deputy chief will be Andrew Leith, Washington, D. C., who was chief of the Manganese-chrome Branch. Harry A. Rapelye, Kansas City, Mo., former chief of the Nickel Branch, becomes special assistant to A. I. Henderson, WPB deputy director-general for operations.

FURNACES FOR *Mass Production*



ROLLER HEARTH—Here's the master of mass-production furnaces. Its war uses include mass copper-brazing, annealing, and sintering of both large and small parts.



MESH BELT—Here's the furnace for copper-brazing, bright-annealing, normalizing, drawing, or sintering lightweight parts. Does the job in one continuous operation.

ELEVATOR FURNACE—For annealing malleable castings, steel castings, tubing, cast iron, sheets, and similar work. Big time saver.

CONVEYOR HARDENING—Here's the furnace recommended for fast, scale-free hardening without decarburization. Just put the parts on a conveyor, and they will go through without further attention.

Feature Articles

The "Achievement Award"

Although it isn't an article in the usual sense, the announcement of M&A's new Annual Award for Engineering Achievement in the Metal Industries (page 598) is important enough to go in the editorial feature section. Be sure to read it!

Conservation — the No. 1 Achievement

Amid the fumbling and hesitancy in gearing the Nation for war production, the many direct and successful steps taken to develop and apply substitutes for scarce metals stand out like a beacon, Gillett (page 600) reports on their success, and indicates where closer attention is still needed.

Washington and the Metal Industries

Since "the emergency" started, the Government's war materials and production program has painfully evolved. Peat (page 608) takes stock of its actual "achievements" in an unusually comprehensive and detailed chronicle and analysis, and includes some comparisons with corresponding progress in World War I.

The National Emergency Steels

As a wartime achievement the development of the NE steels ranks high on the list. Parker (page 622) gives not only the many human-interest angles in this cooperative metallurgical engineering development, but explains the new steels and how to select them for specific services.

The "Military Secret" Achievements

"Now it can *not* be told" is still true of the engineering stories of many of our most important wartime achievements, which must remain "military secrets" for some time to come. Cone (page 630) pays his respects to the foremost among these.

Welded Demolition Bombs

Out of the completely "hush-hush" class comes the American welded demolition bomb, the manufacturing practice for which is presented for the first time by Target (page 634).

Forced-Convection Hardening Furnaces

Users' experience with a recent innovation in heat treating furnaces—a 100 per cent forced-convection unit for temperatures up to 1750 deg. F.—is reported by Peters (page 639).

Preview of The Metal Show

The Preview of the National Metal Congress and Exposition, with information on meetings and programs of the 4 cooperating technical societies, and names and locations of show exhibitors starts on page 663.

Metallurgical Engineering Digests

Cupola Blast Control

The practical principles involved in cupola operations, with particular attention to the pressure, temperature and moisture content of the air blast, are enunciated by Herres and Lorig (page 732).

Coated Welding Electrodes

Weld-rod coatings are discussed by Waldman (page 778) from the standpoints of their requirements, effect on welding practice, and general advantages.

Press-Forming Duralumin Sheet

A practical review of the heat treatment (including refrigeration) and press-forming of plain and alclad duralumin sheet for airframe parts is given by Arrowsmith, Wolfe and Murray (page 740).

Nitrided Cast Iron For Tools

Impressive improvements in tool life of clipping tools for removing flash from forgings are claimed by Thomas (page 796) through the use of nitrided cast iron.

Inside a Jap Aero Engine

Reporting on the metallurgical design of a Japanese aircraft engine, Owens (page 800) finds plenty of nickel, chromium, etc., only one magnesium alloy, and much electroplating.

The Spectrograph in the Steel Mill

Gratifying results of the first year's use of the spectrograph for rapidly doing routine copper, tin and chromium determinations at a large steel mill are reported by Sample (page 820).

War and the Metal-Forms

If engineers in the metal industries once thought their problems in appraising the relative design merits of castings, forgings, weldments, die castings, stampings, etc. were painfully complex, they must be shuddering now at the even worse knots fostered by war-production considerations and at the unholy competitive situation that will be upon us by the time we start rebuilding the war-shattered world.

Just take the drama of iron castings. Gray iron, a couple of decades ago, was losing ground rapidly to steel castings and forgings and to fabricated forms of various types. In recent years, through wholesale improvement in the mechanical properties of gray iron and the spreading of knowledge as to its real capabilities, iron castings were enjoying increasing favor with metal industries' design engineers—even in the face of aggressive competition from welded steel construction. Then came the war, with traditional war-product specifications so stiff that designers just *have* to specify steel castings, forgings, malleable iron or weldments, for many items.

Dozens of specifications are now being revised to permit the use of gray iron where it is clearly good enough for the job—as it is with surprising frequency. But the fact remains that steel castings, forgings and malleable have moved a big jump ahead as a direct result of the war. One currently important factor should not be forgotten by the designer, however—if iron castings *can* be specified, they should be, for iron foundry production facilities are much less jammed than those for the other forms.

The story of stamping is similar. The factors that led engineers to specify them for many peace-time products do not necessarily apply in the case of war products. The country's idle stamping presses class as one of the major heartaches of the war-production changeover.

Screw-machine products recommend themselves for the same reasons as ever—speed of production, high precision and low cost for mass production jobs. But there are now two new factors that may tend to turn the engineer's choice elsewhere—the relative shortness of supply of machine tools and machine-labor, and the material waste often involved in screw-machine forming.

This last consideration has sharply intensified engineering interest in those metal-forms and processes that permit direct manufacture with a minimum of waste-metal removal, such as die casting, cold-heading, powder metallurgy, etc.—although sometimes a specific enthusiast for one or the other requires gentle curbing, since raw material supplies or overall fabricat-

"Gertie" was cut up and fed to the Inland furnaces the day she arrived at the mills.

ing capacity may be smaller than he supposed.

Both die casting and powder metallurgy have been expanded in use by war-production requirements. And when peace-time design considerations return to the fore, we will find the familiar top position of *zinc* alloy for die castings being challenged by *aluminum* alloys. Iron parts made by powder metallurgy, vastly improved by war-production developments, will claim the designer's attention far more than in the past, too. And you'll hear a lot about magnesium extrusions.

Broadly, therefore, the war has in many instances simply changed the relative importance of the various factors that the engineer considers when selecting the metal-form for a given job. In some cases, though, "something new has been added" that will perpetuate the revised concepts beyond the war period. The alert engineer will, therefore, carefully examine *all* the design factors today—*even those he once considered unimportant*—for maximum service to the war effort, and will closely follow those metal-form developments whose extension into the ultimate peace will make some of our 1940 metal-design practices seem hoary by comparison. —F. P. P.

So What?

A lot of plain and fancy worrying is being done about the low temperature properties of metals in respect to aircraft, tanks, armor, and chemical plant equipment, especially in that for synthetic rubber. Many of these worries can be erased at once, for the engineering properties of the non-ferrous metals and alloys, as a group, improve as the temperature drops. The same is true of austenitic steels. With the exception of behavior in the notched bar impact test, the same is true of ferritic steels.

It is known that an axe is likely to chip if it hits a knot when lumbering in zero weather. Even the room temperature impact resistance of hard, high carbon steel, such as is proper for axes, is pretty low anyhow.

The impact resistance of rail steel is pretty low, too, and rails don't wear ear-muffs, yet they don't fly into fragments when a train runs over them in winter, even though a flat wheel may give them some hammering.

The static properties, and even the fatigue and notched-fatigue properties of ferritic steels don't reflect the low-temperature notched bar impact brittleness, so if we can keep out notches and/or impact, we don't need to worry.

That aircraft manage to carry their steel parts to high altitudes and bring them back whole indicates that their service stresses are not of the type that make ferritic steels vulnerable. Tanks sound like something else again, but we haven't heard that either Russian or German tanks fell apart of their own accord last winter, and we don't believe either one has all its parts made from either stainless or 3.50 per cent Ni steel.

Someone once remarked that the notched-bar impact test showed what happens in the notched-bar impact test and not much else. That comment is a little too drastic because we shouldn't close our eyes to any variation in any sort of behavior. Yet we do disregard the notched-bar or other brittleness that tests would reveal, when we use cast iron, zinc-base die castings, plastics (that are "brittles" instead of "plastics" in the cold), enameled steel, porcelain and glass in engineering construction. We use them where the service is such that they are called up for the properties they have, not those they haven't. That is, we mix a little engineering with our metallurgy and chemistry.

Recognition of hazards from misapplication of uses, leads to avoidance of the hazards. Countless shops use cyanide baths for case hardening and many platers use cyanide solution. Because everyone knows that cyanide is a poison, nobody sprinkles solid cyanide on his celery or drinks cyanide when he's thirsty.

When a vessel is used in a low temperature chemical process, even at liquid air temperature, why not cover it with planking so no one can drop a wrench on it? If so protected, why won't ferritic steel serve? —H.W.G.

Metals and Alloys Announces

AN ANNUAL AWARD for ENGINEERING ACHIEVEMENT in the METAL INDUSTRIES

During the last 20 yrs. there has occurred a significant transformation in our industrial structure. This broad development, still approaching its crest, is *the establishment of engineering control in the metal industries* — the placing of design and production practice on a sound engineering basis, the efficient, practical utilization of new discoveries and research developments, and the rise of "the engineer" as the dominant figure in both general management and manufacturing supervision in those industries.

As a result the engineering accomplishments in the metal industries both metal-producing and metal-working during the last decade or two have been tremendous. Particularly in this *war-of-metals period* will the force of recent and current technical achievements be felt with telling impact.

There is thus no better time than now to start paying homage to those specific metal-industries engineering achievements of the broadest importance — not only to give vision and ability their just reward, but to provide a potent incentive for continuing technical advance. And METALS AND ALLOYS, as the engineering magazine of the metal industries, considers it not only this magazine's high privilege but *our special obligation* to be the instrument by which such honor shall henceforth be annually conferred.

METALS AND ALLOYS therefore announces at this time the institution of its ANNUAL AWARD FOR ENGINEERING ACHIEVEMENT IN THE METAL INDUSTRIES. This award will be given every year to that company in either the metal-producing or metal-working industries whose engineers have been responsible for the greatest achievement in production, in manufacturing practice or in engineering design during the two years just prior to the date of award.

The first annual award presentation will be made during the National Metal Congress one year from now — in October, 1943 — and will honor a major engineering achievement that was initiated, developed or consummated, or whose influence was most widely felt, in the period between the middle of 1941 and July 1st, 1943. (The 1943 Award will go to *either* a metal-producing *or* a metal-working plant, but subsequent awards will be made alternately to companies in one field and then in the other.)

Companies desiring to compete for the Award should call their recent important engineering achievements to our attention, to be certain that they receive adequate consideration.

The Award decision will be made each year by an independent Board of Judges, all of whom will be current or past officers of the major technical societies serving the metal industries. This panel, whose exact composition will be announced in an early issue, will have as its non-voting secretary Edwin F. Cone, editor of this magazine. Neither the publishers nor any of the employes of METALS AND ALLOYS will have any voice or influence in the final selection.

Details of the Plan of Award

1. This Award shall be known officially as the METALS AND ALLOYS ANNUAL AWARD FOR ENGINEERING ACHIEVEMENT IN THE METAL INDUSTRIES. It shall consist of a suitably-inscribed plaque, to become the permanent possession of each annual winner.

2. The Award shall be made each year to that company in either the metal-producing or metal-working industries whose engineers have been responsible for the greatest achievement in production, manufacturing practice or engineering design during the (approximately) two years just prior to the time of Award.

3. The Award-winning achievement may be a "new" development—one that was initiated, developed or consummated during the 2-yr. period covered—or it may be for an older development whose great and good influence had not been completely felt until the present period.

4. Any company that makes, processes, fabricates or uses metals or metal-products as the primary feature of its manufacturing operations shall be eligible to enter the specific achievements of its engineers in this competition. The fact that a company is or is not a subscriber to or advertiser in METALS AND ALLOYS will have no bearing whatever on the admissibility or success of its entry.

5. Entries for the 1943 Award will close on July 1st, 1943. Nominations may be made by a competing company or by any one by sending the Award Secretary, METALS AND ALLOYS, 330 West 42nd St., New York a memorandum stating the exact technical nature of the achievement and its significance to industry as a whole, and demonstrating the immensity of the problem solved and the ingenuity of the development itself; and including whatever factual and descriptive exhibits are necessary to prove that the development in question was a major engineering achievement and worthy of an award. This procedure will assure consideration for a specific achievement, although the Board of Judges *may* confer the Award on an achievement not formally entered in the competition by the company responsible.

6. The Award decision will be made by an independent Board of Judges (names to be announced later), which will consist of a group of eminent engineers, all currently or recently officers of the major technical societies serving the metal industries.

This "Engineering Achievements" Issue

The October ("Metal-Show") issues of METALS AND ALLOYS have in recent years been dedicated to some special editorial theme of timely importance — in 1940 the theme was "Metallurgical Engineering in Defense" and last year "Faster Production for Defense." *This* year — paralleling the institution of the "Achievement Award" announced on the preceding page — we dedicate the October issue to the theme "Wartime Engineering Achievements in the Metal Industries" and pay our compliments to a few of the outstanding technical and industrial accomplishments of recent months in our field.

Despite our painfully slow military progress and the still exasperatingly low quantity-level of some classes of war production, the wartime achievements of the metal industries and their engineers have actually been tremendous. Production increases of several hundred per cent in some lines, the widespread adoption of materials, designs and practices to extend our hard-pressed metal-supply to the very limit, technical developments that vastly improved the striking power or resistance of our fighting tools and armament — these have been the answers of America's metal industries to the obvious and urgent necessity of *engineering our way to victory!*

Only a small part of the overall achievement and a tiny fraction of the specific technical accomplishments can be reported in this issue. The physical limitations of space and the necessary restrictions of military secrecy prevent our discussing a host of developments, many of which are as important as those reviewed on the pages that follow.

Dr. Gillett's article on the conservation achievement, Mr. Peat's on Washington's material-control program and Mr. Parker's on the National Emergency (NE) steels, provide a broad review of achievements that can be called nation-wide in scope (and almost in initiative, too); these have largely been group accomplishments and are properly hailed as such.

The other articles — Mr. Cone's on the chiefly "secret" achievements, Mr. Target's on welded bombs, and Mr. Peters' on a heat treating furnace innovation — describe specific achievements by individuals or companies that properly classify as outstanding. Many others, not described in this issue, are equally outstanding — in other words, the specific achievements discussed in the 3 articles just mentioned are not necessarily the top achievements, but are certainly among the leaders.

In conjunction with the Award Announcement on the facing page, we should also mention that the specific (company or individual) engineering achievements described in these articles are typical of those that would be suitable for consideration for METALS AND ALLOYS' Achievement Award.

Future October issues of this magazine will also be dedicated to the "engineering achievement" theme, and will contain as the leading editorial feature the engineering story of the development that is receiving the Award that year as well as descriptive articles about the most meritorious achievements that were under consideration. Special honor will thus attach to articles in future October issues of METALS AND ALLOYS, which will become the place where metal-industries men will expect each year to read — often for the first time — the complete engineering or metallurgical stories of the major pioneering production and design developments of the period.

—The Editors.

Conservation and Substitution—So Far

by H. W. GILLETT

Editorial Director

The "substitution" phase of the overall conservation problem has been one of the toughest wartime nuts for industry's engineers to crack. A reasonable substitute one day would be placed on the scarce list the next. As the author says, "changing from one substitute to another as degrees of tightness vary, makes the materials engineer lead a grasshopper life, but it is his ability to hop that gets him out of many a predicament." Such nimbleness is a major accomplishment, to say the least, but the achievement that we hail via this aritcle is the broad nation-wide conservation effort and its actual results and benefits. At present it is an achievement that must be classed as "unfinished" until the war is won.—The Editors

The dies being checked here represent a major use of alloy steels and a field in which the program to conserve materials has been most intense. (Courtesy: Westinghouse Electric & Mfg. Co.)

THE WASHINGTON PLANNERS didn't admit Ethel Barrymore to their councils until less than two years ago. That a situation could arise in raw materials where Ethel's phrase, as she took her final bow, "That's all there is, there isn't any more," would sum up the case, was not generally recognized.

In time that possibility began to be recognized, and even back in the "defense" and "lease-lend" days it had become more than a possibility, for, even then shortages began to crop up, notably in copper, nickel, zinc, and tungsten, and it became fairly obvious that a shortage of any industrial metal might impend. Increased production and importation, and development of domestic low-grade ores were resorted to, and to protect the supplies, groups were set up to watch the production and consumption statistics and trends, and to allocate the supply of each individual metal. The mechanics of conservation were to take the metal away from whatever uses were appraised as non-essential, but lavish use in essential applications was, for a time, accepted as inevitable. Altering specifications to take less of the metal but still provide the essential engineering properties was not yet tackled, the specifications and practices of the Army and Navy in particular, remained sacred cows.

Taking away one metal from its accustomed "non-essential" uses, led to private substitution, first, of other standard alloys of properties equivalent for many purposes, *e.g.*, chromium-vanadium and chromium-molybdenum steels for those high in nickel. Quite promptly, vanadium became tight, and for quite a period molybdenum was the life saver, but it was used in over-generous amounts. This drain, coupled with the shift from tungsten to molybdenum high speed — a shift obviously feasible on the basis of long experience and only lacking of full accomplishment much earlier because of sheer inertia — made molybdenum tight in its turn. Increased supplies of domestic tungsten lately came in to help this situation.

Substituting for the substitute and changing from one substitute to another as degrees of tightness vary, make the materials engineer lead a grasshopper life, but it is his ability to hop that gets him out of many a predicament.

Alloy Steel Scrap and the N. E. Steels

Utilization of alloy steel scrap so as to put all its components to maximum use is highly important. This is what the National Emergency steels accomplish. These steels, carrying small amounts of several alloying elements, are capable of depth-hardening to the same degree as a steel containing really large amounts of a single alloying element, or of such amounts plus a minor amount of another to correct some shortcomings. These new Irish stew steels, usually with Grainal or analogous treatment; *i.e.*, with a trace of special seasoning, whose effectiveness is just being realized by the metallurgist, though he still doesn't exactly understand the reason, will serve equally as well in lots of uses, as the old highly alloyed SAE steels. Moreover, the final step to plain carbon steel plus proper heat treatment is likely to be feasible in an astonishing number of cases.

To use alloy-free or alloy-poor steels, specifications will have to be based on properties desired and the maker allowed to get the properties in the most feasible way, feasibility relating primarily to the available alloy scrap and to the momentary availability of particular alloying elements to provide a few tenths or hundredths of the sweetening that may be required, as well as to available heat-treating equipment. Not every old furnace will do the precise heating job that is required.

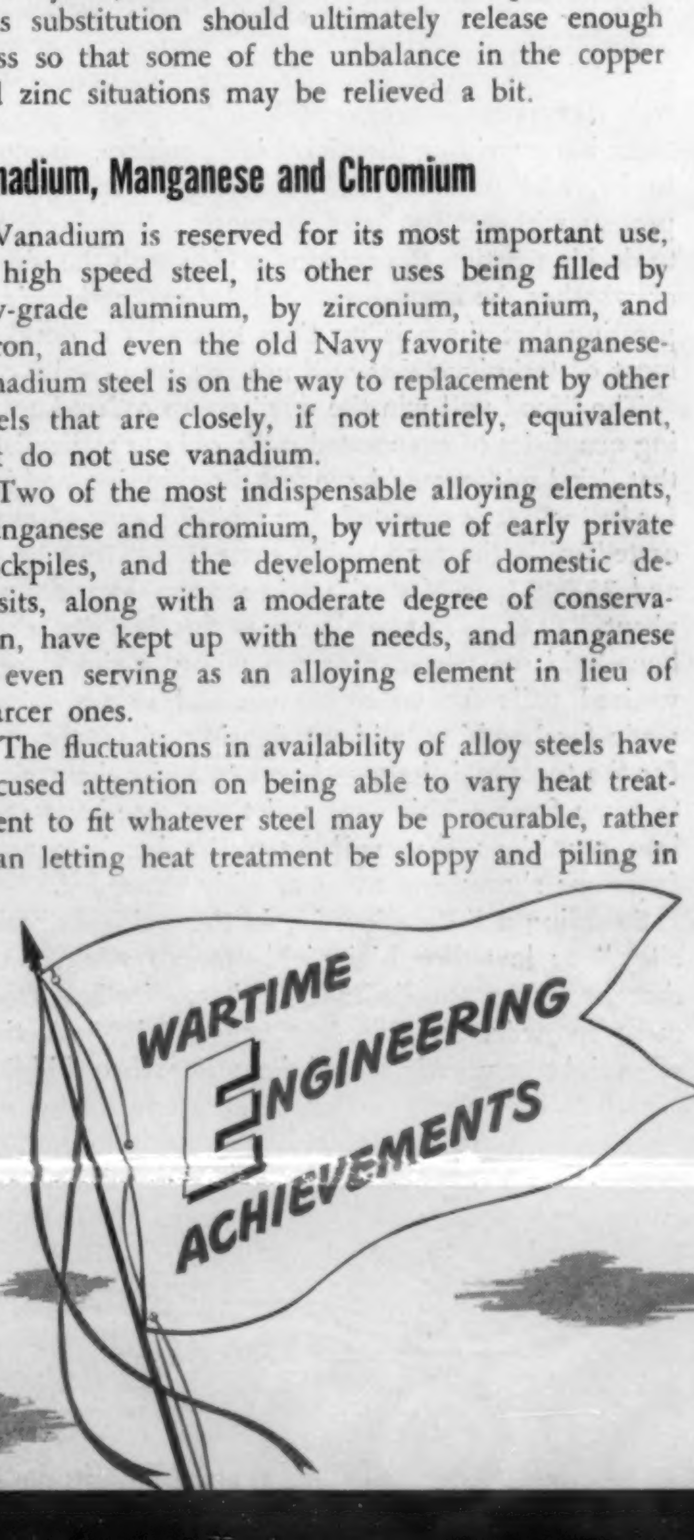
Meanwhile, "emergency specifications" for many steels and other alloys have been worked out that do deal solely with getting the properties necessary, forgetting "virgin metals" and like fetishes. The need for cartridges led to the development of a steel cartridge case that would shoot and would extract from the breech, even though it may not have the corrosion resistance of the brass case. Since we're figuring on shooting them rather than storing them for 20 years, the steel case fills the true specification. This substitution should ultimately release enough brass so that some of the unbalance in the copper and zinc situations may be relieved a bit.

Vanadium, Manganese and Chromium

Vanadium is reserved for its most important use, in high speed steel, its other uses being filled by low-grade aluminum, by zirconium, titanium, and boron, and even the old Navy favorite manganese-vanadium steel is on the way to replacement by other steels that are closely, if not entirely, equivalent, but do not use vanadium.

Two of the most indispensable alloying elements, manganese and chromium, by virtue of early private stockpiles, and the development of domestic deposits, along with a moderate degree of conservation, have kept up with the needs, and manganese is even serving as an alloying element in lieu of scarcer ones.

The fluctuations in availability of alloy steels have focused attention on being able to vary heat treatment to fit whatever steel may be procurable, rather than letting heat treatment be sloppy and piling in



lots of alloy so that the sloppiness may get by. Further changes in availability may be expected.

Magnesium Production and Use

If a better incendiary bomb than one of magnesium is found, the magnesium capacity planned might still be used and the magnesium applied more widely to take the place of aluminum in aircraft. This would release aluminum, as would the use of mechanically stiffened carbon or mild alloy steel instead of aluminum in aircraft. Aluminum might then substitute for copper and for tin in many applications.

The expansion of aluminum and magnesium production has been one of the marvels of the emergency. It was possible because it was carried out by people who knew their chemistry, metallurgy, and engineering. Step by step we are on the road toward "aluminum from clay," and without undue violation of economics, considering the need. Even more spectacular is magnesium from sea water. The Hansgirg magnesium attempt was a spectacular flop, because all it had was engineering; it lacked chemical and metallurgical knowledge.

Probably not too hot as to economics, but valuable for speedy installation, the silicon reduction process for magnesium is an example of the conflicting features of most rush production and most substitution problems. The known workable setup for producing magnesium from its oxide through reduction by silicon takes nickel-chromium heat resistant alloy retorts, but providing the nickel is a problem. It ought to be, and probably is, possible to carry out the process without that type of retorts. Somebody has to decide whether the magnesium is worth the nickel, or whether the immediate need for magnesium is so pressing that there is no time to wait for development of technique that will not require nickel.

The "food will win the war" group ordered amazing quantities of evaporated milk, only to realize later that dried milk would have met the shipping problem far better. It is reported that a billion cans of evaporated milk, the cans taking some 1,250 tons of tin and 75,000 tons of steel are in storage—a white elephant. O.C.D. at one time was figuring that every household must have a stirrup pump, a shovel, galvanized pails for water storage and so on, to get ready for bombing, without figuring where the steel for the tools and the man-hours to make them, were to come from. This steel and these man-hours, put into munitions that will keep the bombers away from our shores, are more sensibly expended.

Spending a little alloy, *i.e.* in the weldable "mild alloy," or low-alloy high-yield-strength steels, those that are strong as-rolled and don't require heat treatment in order to save lots of steel by reduction of weight required, would be wiser than kidding ourselves that we're saving alloy elements by not using them where they are a wise expenditure, particularly since manganese, the least tight of all the alloying elements, can do most of the work.

Conservation is proper use, not storage. A willingness to swap a small weight of one critical material (even if it's the one it's your own job to conserve) for a much larger weight of another, or even a lot of a relatively plentiful one for a little of a very scarce one, i.e., *to put each material where it will do most good,* is what we shall have to come to. Fortunately, we have become sufficiently raw-material-conscious so that things are getting to be looked at from that point of view.

The Silver Problem

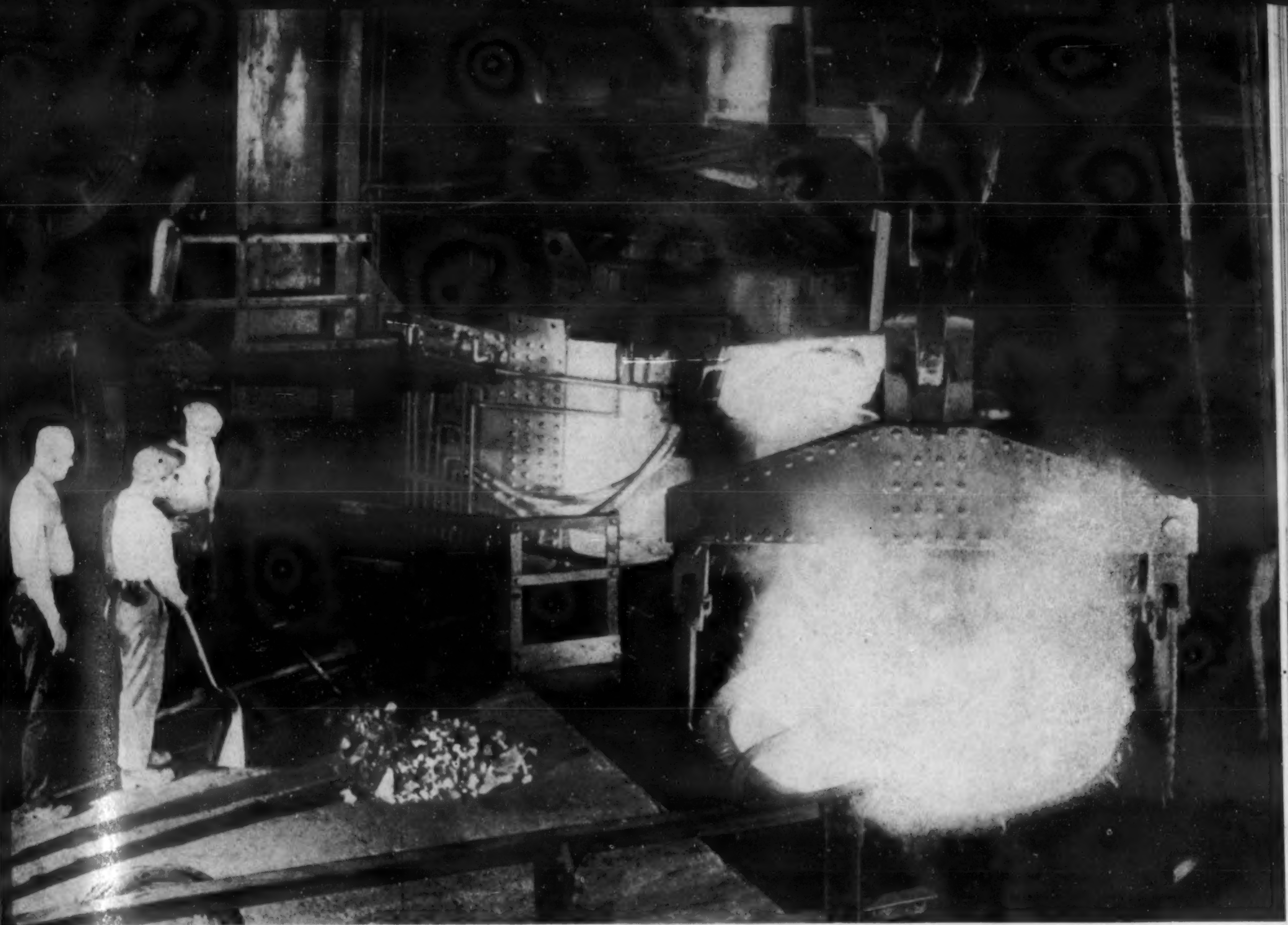
Balancing is not always a simple problem. Whether it is better to use 3/10,000 of our annual copper supply or 3/500 of our annual mercury supply for treatment of seed wheat is a matter for thought. The ratio of replacement of mercury for copper is high, but the total available tonnage of mercury is small. We are getting both copper and mercury in more than normal supply and using both in far more than normal amounts. For this particular purpose, we can use whichever one it is wisest to use, and that depends on the conditions of supply and of most urgent demand.

When we are getting far less than usual of one metal and have large stocks of another that has a high replacement ratio for the first, there is no question as to the advisability of using the latter; it's a necessity to do so.

This is the case with solder, where 2 per cent silver will take the place of 30 per cent tin. The technical man is ready to make this switch and has made it as far as he can, only to run into the jackass politicians working for the votes of pressure groups. How to pry loose enough silver from our buried store to meet the war requirements that silver will meet, in spite of these politicians, has been a real problem. It seems that the domestic JAPs needed licking as much as the foreign ones.

In a masterpiece of phraseology, an Aug. 21 W.P.B. press release put the situation then existing in these words, "Silver is commercially scarce, though large stocks exist in this country." Since then the price of industrial silver has been raised to 45c per troy oz. to encourage Mexican and Canadian production, while most of our own stockpile, bought at an excessive price from political motives, still lay buried. However, the loaning of Treasury silver for conductors to replace copper was a straw in the wind to indicate that when dire scarcity necessitated, release of stockpile silver might come for other war uses, even like that in solder, where some of the silver will not be recovered.

It has taken a long time to get as far as we have on the road to the use of our buried silver, but a



In the manufacture of alloy steels in electric furnaces, conservation and substitution of alloying elements have been major factors. (Courtesy: U. S. Steel Corp.)

Sept. 18 statement from the Treasury at last says that 187 tons of silver will now be sold outright at the 45c price to industrial users with high priority ratings.

A "Silver Users' Emergency Committee" attempted to "enlist public opinion" to force Congress "to bring silver out of government hoarding vaults and into productive use," a laudable purpose as it is stated in the quoted words. Unfortunately, there seems to be mixed up in this the feeling by some jewelers that making silver gadgets for wedding presents, and so on, is "productive." Such use is a long way from the truly productive uses in solders and bearings, for silver saves tin in bearings, too. Pressure groups and politicians that use patriotic words to conceal ulterior motives and mix up worthy and unworthy objects tend to make it harder to accomplish the worthy ones.

The politicians are also a thorn in the flesh through their efforts to get government funds, from the authorities that can hand them out for raw material production, for unusable ore deposits and unworkable processes controlled by their constituents. A notable case is in all the hullabaloo about sponge iron as a substitute for scrap which we discussed editorially in the August issue. Political metallurgy is weird and wonderful.

Steel and Copper

Substitution of synthetic scrap, *i.e.*, increasing blast furnace and coke capacity for pig iron and use of pig iron, plus ore added to the melting furnace (even though this is a bit hard on the lining), or partly blown down in the converter, and scouring the country for scrap, plus increased ore, mining, and transportation facilities, and great increases in electric furnace capacity so that alloying elements may be retained, are the major features in conservation in steel production. Since the planned production capacity for steel is 10-fold that of all the other metals put together, steel, cast iron, and malleable are the materials to be substituted for non-ferrous ones wherever that is possible, and a change to non-metals is not possible. Balancing of the use of processing equipment so that no installed facilities be idle, is the ma-

Checking the sub-assembly of a cupola for the top of a gun turret of a 28-ton tank. In making a cast armor plate for tanks, substitution and conservation of alloys have been widely practiced. (F.P.G. picture)

jor task here. Re-admission of converter steel long ago made an outcast by effective action of a pressure group, into the family of respectable steels will help, use of malleable will increase, and more use of gray iron will probably follow. Using these weaker and more brittle, but more easily made, irons instead of steel when the product doesn't really need much strength or toughness, is good engineering. Cast-iron propellers for ships are known to work; it's sense to use them for freighters instead of steel or bronze.

In this war of metals, our first thought is naturally to conserve a metal of which the supply is small by substitution of a more plentiful one. Since our productive capacity for iron and steel is so much greater than for all other metals, we lean back upon the ferrous metals in every case where they'll do, and are now at the point where we could use more steel than we can get. Hence we go to wood, notably in truck bodies where we can save 350,000 tons of steel a year, though that means producing a million board feet of lumber every day of the year. The smaller pieces from getting out boards for truck bodies make wooden cots. We can go on from there and make clothespins and matches from still smaller pieces.

Using what one has doesn't mean that the product need be inferior. The Eskimo has skins as raw material. From them he makes a kayak that exactly fills his need. The Crees of Quebec use cedar shakes, spruce root and birch bark for canoes and pitch them with spruce gum plasticized with bear grease, and they are good canoes. When they can get it, they may use asphalt roofing pitch, if they happen to get to civilization and a hardware store. Thus this avoids having to shoot a bear, but they don't cry if they can get none but local materials.

Saving steel by not using it for bobby pins and coat hangers sounds childish at first, but "mony a mickle makes a muckle," and the aggregate of minor uses, each "too small to have any effect" can add up to a lot. It doesn't make much difference whether a single lead pencil has a brass ferrule or one of the new non-metallic ones, but when it comes to a recent government requisition for 13,000,000 pencils, to meet the usual specifications, *i.e.*, with brass ferrules, those ferrules add up to quite some cartridge cases.

Similarly, in assembling 150,000,000 ration books, gluing instead of using wire staples saves a good many miles of steel wire.

Copper is conserved by shifting to brass where either will serve, by lowering the copper content in other alloys, to a slight degree by loan of silver for electrical conductors, and will be greatly conserved by the inevitable shift to steel for cartridge cases. Redesign of bronze freight car bearings to use a thinly lined steel or back would release a worthwhile amount

of both copper and tin, but even with the application of all possible savings and substitutions pending the time where there might be a surplus of aluminum, the copper situation will remain one of the tightest.

It seems incredible that the supply of steel and copper, all devoted to direct or indirect war uses, should be insufficient to occupy all the man and woman-hours available for their fabrication or insufficient to provide adequate fighting tools for all the fighting forces we can muster. The building of plants and equipment, a phase now pretty well over, and accumulation of necessary inventories for working materials, which, once filled, will not need to be increased, create a temporary drain that will be much reduced when raw materials come in at one end and finished goods come out of the other.

But we also have to supply fighting tools and civilian needs to all the non-barbarian world and have to deliver them too, and it seems to be this that will force the utmost in conservation and substitution, indefinitely. By this token, too, we should not stand for being imposed upon by foreign specifications drawn in times of plenty and never revised.

This will bear enlarging upon. It is much the easier way for a foreign engineer to call for just what he has always used, in the hope that Santa Claus will bring it, than it is to revamp his technique. We are too prone to act as Santa Claus and export just what the foreigner asks for, instead of exporting information on how to use what he already has available, when raw materials are involved, and too prone, in the case of finished goods, to make every part out of just what the purchaser or lease-lend borrower says to make them of, instead of using more plentiful substitute materials that we know are at least as suitable for the purpose. We are getting real tough with ourselves, internally, and it's time to get equally tough with those we supply.

For a while, this attitude of not "risking" quality by modifying specifications to keep up with advances in engineering know-how was not entirely absent from our own armed services, and we can fully sympathize with the desire of the Army that our guns, ammunition, tanks, etc., shall kill the right people, of the Navy that ships shall not break down while a sub is hanging around, or of the Air Force that a plane shall not break up in the air. However, when it is possible, as it often is, to make perfectly good guns, ships, planes, etc. with less lavish use of scarce materials and so make *more* of them to kill *more* of the right people, we ought to do it, and the generals and admirals are all for it. The mechanics of proving that the *more* material is still good material and getting the substitutions in effect through specifications and on down to the last inspector, are not too easy, but we're on our way. Orders to make use of proven substitutes have been sent out from the tops of the Services. Implementing those orders in respect to everything used by the Services and doing it promptly, add up to a tremendously detailed task.

An important method toward unchoking the whole metal situation, especially in respect to copper, and to aluminum and alloy steel as well, is segregation of scrap at the source, instead of mixing various grades. Pending complete application of this, and to utilize other scrap, specifications for copper alloys that can only be met by virgin metals, need revision to allow impurity content proven to be quite harmless.

You can re-use an alloy time and again if you don't gum it up with alloys that ought not to be there. Spent brass cartridge cases, remelted and reworked, make good new cases, but mix the cartridge scrap in with faucets, and the mix doesn't make cartridge cases at all, and not very good faucets. You can handpick faucets out from cartridge cases, though it's a waste of time to have to do so, but when machine shop chips get mixed, you can't do that. The time to catch the chips is when they're a-borning, so every well regulated shop now has a special receptacle, right at the machine, for each kind of chips. With "a place for everything and everything in its place," scrap becomes *pedigreed* scrap, quite as valuable as new metal, while *mongrel* scrap is vastly degraded in utility.

In analogous fashion, the tungsten-molybdenum, vanadium high speed steel situation can be materially helped by better return of used-up tools.

Spreading Nickel Thinly

Nickel is being spread more thinly; nickel steels of tomorrow will mean about 0.50 per cent instead of 3.50 per cent, for hardenability will be gained by a multiplicity of tiny amounts of different elements. Copper is not being used much to take the place of other alloy metals in ferrous compositions, but it would be a very sensible swap in the eyes of everybody but those policing copper.

The heat-resistant nickel-chromium alloys are getting along with lower nickel content, but austenitic stainless nickel-chromium welding rod is needed for armor welding, pending success in attempting to find a substitute. New demands for stainless steel for its corrosion resistance and for structural uses, where its strength rather than its corrosion resistance is wanted, come up constantly. The structural uses need close examination, for some are clearly substitutable. Stainless-clad, *i.e.,* ordinary steel with a veneer of stainless, deserves to be more widely used for corrosion-resistant service. We need more facilities for producing stainless-clad and more experience in its use. It is claimed that manganese can be quite widely used to substitute for part of the nickel in stainless used for structural purposes (making a partially ferritic alloy instead of an austenitic one) and

Material	*Domestic Deposits Developed*	*Processes for Using Low Grade Ore Developed*	*Scrap Utilized*	*Non-Essential Uses Dropped*	*Alloying Percentage Decreased*	*Partly Replaced by*	*Further Possible Steps*
Steel	Yes	Yes	Yes	Yes	No	Wood, ceramics, glass, plastics	Same lines
Copper	Yes	Yes	Yes	Yes	No	Steel, zinc, silver, plastics, wood, paint, plating	R. R. bearings
Zinc	Yes	Yes	Yes	Yes	No	Steel, lead, plastics, wood, ceramics	Same lines
Lead	Yes	No	Yes	Yes	No	No	Supply adequate at present
Aluminum	Yes	Yes	Yes	Yes	No	Copper, steel, plywood, etc.	Same lines
Magnesium	Yes	Yes	Yes	Yes	No	Aluminum	Same lines
Manganese	Yes	Yes	Yes	Yes	Yes	No	Same lines
Chromium	Yes	Yes	Yes	Yes	Yes	Manganese, silicon	Same lines and clad metal
Nickel	No	No	Yes	Yes	Yes	Manganese, silicon, chromium, molybdenum, silver, etc.	Same lines and clad metal
Molybdenum	Yes	Yes	Yes	Yes	Yes	Silicon, tungsten, chromium	Better return of scrap tools
Tungsten	Yes	Yes	Yes	Yes	Yes	Molybdenum, titanium, and tantalum in carbides	Better return of scrap tools
Vanadium	Yes	Yes	Yes	Yes	Yes	Aluminum, zirconium, titanium, boron, platinum (as catalyst)	Better return of scrap tools
Antimony	No	No	Yes	Yes	Yes	No	Same lines
Mercury	Yes	Yes	No	Yes	No	Lead azide for fulminate	Same lines
Tin	Yes[a]	Yes	Yes	Yes	Yes	Organic coatings. Glass, silver, zinc, silicon, lead	Same lines
Titanium	Yes	Yes	No	No	No	—	Same lines

[a] **Low-grade South American deposits, no domestic deposits.**

What has been, and could be, done

to some degree for corrosion and heat resisting uses, but there are limits to such substitution on the score of performance.

The shift from riveted to cast and welded armor has temporarily called for high nickel steel, but the nickel content has been reduced and may be eliminated. The extent to which nickel-saving is necessary is evidenced by the plan to make "nickels" with copper, silver, and manganese instead of copper and nickel.

The main war use of zinc is in brass for cartridge cases, but zinc-base die castings have done yeoman service in substituting for other alloys that have to be fabricated by more laborious processes. Germany has used zinc copiously for things ordinarily made out of brass to save her scarcer copper, but we have had to skimp on zinc nearly as much as on copper.

In an intelligent scheme of engineering the necessary combination of strength, lightness, and stiffness into aircraft parts now made of aluminum, low-carbon steel sheets, like those used for the tin can, are welded to a stiffening expanded steel backing, like the expanded metal lath used to hold the plaster on walls. To provide corrosion resistance, when the camouflage paint, required anyhow, is insufficient, electroplating the exposed steel surface with zinc may be practiced. This appeals to the conservationist as much more sensible than using cold worked stainless steel whose strength and corrosion resistance are very satisfactory, but which takes large amounts of chromium and nickel. We can certainly get unalloyed plain steel and zinc to coat it from our plentiful domestic deposits of good grade iron ore and zinc ore more easily than we can utilize the domestic low grade deposits of chromium ore or increase the supply of imported nickel.

Thus, with proper engineering, iron substitutes for nickel and zinc substitutes for chromium.

Nothing very drastic has been done about antimony. Its content in battery plates has been limited, but not to any degree of real hardship, and its feasible substitution there has not had to be resorted to.

The Hardship in Tin

Where some hardship has come in, is in respect to tin. Tin is really a tougher proposition than rubber, for given time, we can make substitutes that have the properties of rubber, but when you use something else, such as glass, instead of tin, you get a different set of properties, and have to engineer the whole

process to suit those properties. When you do this, you come out all right. Tin seems to be better off than rubber, because there has been technical planning for getting along without it. That is, we know more about engineering substitutes for tin than we do about synthetic rubber.

We don't need tin-base babbitts; lead-base babbitts will do the work; other bronzes such as silicon-bronze, will do nicely for general bronze castings and even the bronze alloys for bearings should ultimately prove to need no tin other than that from scrap.

Lead burning can replace wiping solder. Other tin solders are nicely substituted by lead-silver, except for soldering black iron or bonderized stock. Some further information and some educational spreading of information on technique will be needed to complete the solder substitution.

The major remaining use for tin is for food canning, which cans used to be made from hot-dipped tin plate that, because of the nature of the hot-dipping process, had to have a certain average thickness; it couldn't be squeezed any lower, but that average thickness was made up of some thin, but thick enough, places and a lot of places that were thicker than necessary. By electroplating, we can put on just the average we want, and no more, and make the coating uniform, to boot. The can makers and the National Canners' Association have had a most constructive attitude. Long before Pearl Harbor they were scheduling for the present canning season, canning tests in cans made from thinly coated electrolytic tin plate and from lacquered bonderized steel with no tin in it at all, to fill in gaps in information, though the gaps were astonishingly small. They will be ready to put electrolytic and bonderized stocks to satisfactory uses just as fast as the steel mills can supply them, with a consequent vast reduction in tin needs. Something like one-fifth the tin we used to use for tin cans will do a real good job. But even this isn't the final answer; we can go still further and preserve food without tin.

Dehydration, freezing, and packaging in non-metallic containers are also developing fast. Probably the more corrosive products that would otherwise need hot-dipped tin plate will ultimately all go in glass or else not be canned at all. Nutritionists are listing the things we can do without if we have to. We shed a personal tear at the possibility of having to go without cherry pie, and hope the glassmakers allow that contingency to be avoided.

Collapsible tube packaging in tin has practically ceased. Lead tubes, with synthetic organic linings of the rubber-like type, serve for many products. Foil for packaging is practically out, with no harm ensuing.

Reclamation of used tin cans, uneconomic under normal conditions, is being resorted to, and this is sensible, for it furnishes a supply of steel scrap beneficiated by removal of tin as well as a small amount of reclaimed tin, killing two birds with one stone.

The growing pains of the Texas tin smelter will doubtless be smoothed away, and if importation of Bolivian tin ore is kept up, the country's stockpile of tin should tide us over until substitutions can be put into full effect, and imports from South America should provide the irreducible minimum.

The most vital need for effective conservation of tin is the early completion of the electrolytic tinning and the bonderizing lines.

We remember the darky washwoman in the South who was late in bringing the washing. She explained that her pump was out of order and said, "Mr. Roundtree could have fixed it, but he didn't have the fixtriments." Getting the fixtriments necessary to vitalize a known technique for substitution, from a dormant possibility to an accomplished fact, comes into practically every substitution problem.

Cobalt, Beryllium, Boron, etc.

Among the minor metals, cobalt, beryllium and cadmium, supplies of which are difficult to increase, are being restricted to their more essential uses. Mercury, whose uses are chemical rather than metallurgical, and titanium, whose major role is as the oxide in pigments and opacifiers, but which can sometimes act as understudy for vanadium, are both being supplied from domestic or nearby mines.

Elements of which our domestic supplies are inexhaustible are silicon, phosphorus and boron. As a reducing agent, and as an alloying element, silicon is serving well. Despite the back seat into which the mild alloy steels were pushed at the start of the emergency, some of the phosphorus-containing mild alloy steels are edging their way into munitions manufacture, because of special suitability of their properties. Boron is rapidly assuming importance in conferring depth-hardening on steel.

For producing these and the other electrically smelted alloying elements, the provision of electric generating facilities has been kept well up toward the requirements, and there is no lack of coal (in the mines, at least) for the steam plants, and in the present season, no lack of rainfall for the hydro plants. Rail transportation has been kept up in a very satisfactory way.

All the achievements in supplying unprecedented amounts of metals, in apportioning them to the uses and in the amounts where they do the most good, and in utilizing substitutes, can be summarized as the application of sound engineering principles. The economic conditions were vastly changed from those obtaining previously, and were moreover under continuous change, so that the best way to do a thing last month, this month, and the next month, may bear little resemblance to each other. The flexibility of thought and practice resulting from this experience will be a permanent national asset.

Washington's War-Materials Achievements

by LESLIE PEAT

It is still too early to class Washington's programs and policies for expanding and augmenting our metal supplies, overcoming shortages, allocating available materials in the best stragetic interests, etc., as an unequivocable achievement. The effort is too complex and its effects still too hazily visible to warrant a positive judgment. But there is no better time than the present to take stock, realistically and objectively, of our progress and actual achievements in materials-controls, so that we may see (and continue) what is good, and recognize (and correct) that which is bad. Mr. Peat—an experienced Washington correspondent for several industrial magazines—attempts here the colossal task of interpreting Washington's metals-developments to date for metal-industries engineers, who—if our ear to the ground has not misled us—will henceforth have increasing responsibility in the handling of the metals program in the Nation's Capital. —*The Editors*

"NOTHING IS GREAT or small save by comparison," stated Swift in "Gulliver's Travels." In rating our war efforts at the Capital the only yardstick is World War I, unsatisfactory as this may be.

The present is a "total war," not only because every man, woman and child is involved actively but because a far greater part of the world is now shouldering arms. Now we are the "arsenal for democracy." During the first war our A.E.F. was fighting chiefly with French and English arms and ammunition.

In both wars we had advance warning that we might become involved actively. Besides, in case of World War II we had the precedent of World War I, which indicated we could be dragged in a second time despite our isolationists and youth movement consecrated against ever fighting on foreign soil again.

Over-all, our accomplishments in this era have

First meeting of War Manpower Commission. Front row: Donald M. Nelson, C. R. Wickard, P. V. McNutt, Frances Perkins, J. V. Forrestal. Back row: Wendell Lund, G. H. Dorr, L. B. Hershey, A. J. Altmeyer, A. S. Flemming, F. W. Harper.

been truly remarkable despite all the fuzzy-wuzzy planning and execution. The fact that Government itself placed many silly hurdles in production's path makes the final accomplishment all the more brilliant. During World War I even Wilson's democratic government was not hostile towards big business. During the F. D. Roosevelt era big business has ever been sniped at, both directly and through glorification of the labor union.

In this era Dollar-a-Year Men have been sniffed at, as being tainted by big business. Anti-trust suits and persecutions have enjoyed a field day. Steel men have frequently not been placed in charge of Government agencies dealing with steel lest they favor their own companies.

Too much has the New Deal spirit of experimentation been carried over to war activity. Industry would have worked out priorities, allocations and inventory appraisal in a practical manner from the start and as they applied them to their own successful individual industries, if given the nod and authority. Hard-headed men of industry would have profited by trial and error methods in Britain. We were adopting certain methods of materials distribution just after Britain had abandoned them. Many an older steel man commented on the superior set-up at Washington during the first war, at least in some departments.

Of course it must be admitted that running War I was child's play compared with this. That was the war where the foot soldier with gun and bayonet counted most. In this war the mechanized weapon, precise as a Tiffany watch, is supreme. Towards the end of the first war, Ford was turning out a $3\frac{1}{2}$-ton tank, which, compared with a General Grant or General Lee, looked like a kid's skooter.

If in the first war anyone had mentioned a production program of 60,000 airplanes, 45,000 tanks, 20,000 anti-aircraft guns and 9,000,000 tons of shipping in 1942 he would have been looked upon as a Jules Verne romancer. The war plane then weighed one-fifth the present plane and was made of canvas, wire and wood parts as again the all-metal plane today. It has been said that the first world war ushered in a golden era of the chemical industry and that this war is ushering in an aluminum-magnesium age of metals.

Some Comparisons

In 1918 production of aluminum was 65,000 tons! in 1943 it should reach 1,250,000 tons; in 1918 production of magnesium here was 142 tons; in 1942 it will be 85,000 tons with a goal of 300,000 tons.

Using steel as a production barometer for metals generally, steel ingot production in 1917, the peak of that era, was 45,000,000 tons as against close to 90,000,000 tons today. Moreover ton for ton, steel goes farther today since for a given strength in 1917, the same strength today means more lightness. One might say that 45,000,000 tons of steel in 1917 is equivalent to 55,000,000 tons, or more, today in this era of alloys.

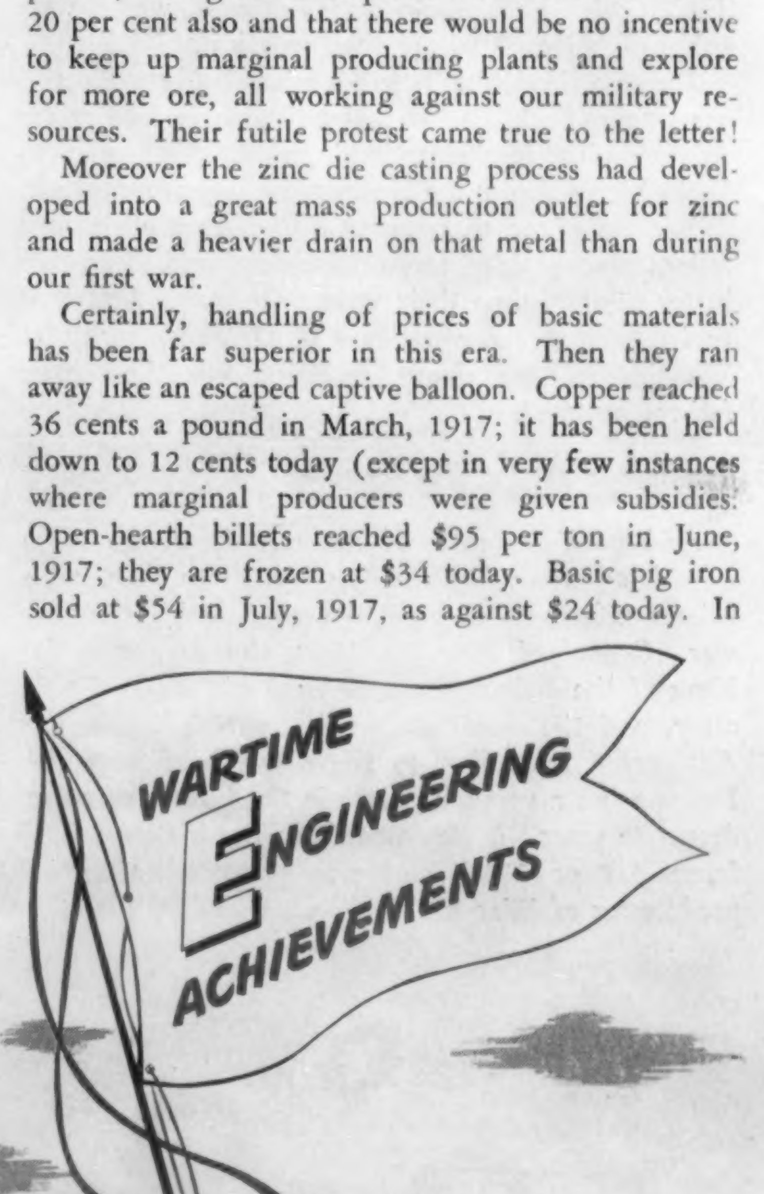
We were off to a good war start on Pearl Harbor day because of accumulations of strategic materials. We had 14 months' supply of tin and a year's supply of rubber, for instance, though actually this advantage over War I was nullified by the unexpected seizure of vital war materials in the Western Pacific by the Japs.

Memories of the gross surpluses that existed after the first war made our industrialists reluctant to expand capacity in the early phase of *this* emergency. The copper industry took an awful beating because of surplus stocks in 1919. The "everlasting metal" was too everlasting and it took financial wizards to stave off chaos throughout the industry. Second hand war steel plagued the steel industry for years and caused permanent shut downs of the weaker companies. With this in mind, Walter S. Tower's impossibly light estimate of defense needs can be understood when he said, in the fall of 1940, that only 8,000,000 to 10,000,000 tons of steel would be needed yearly for defense. That was of course a year before Pearl Harbor.

On one critical metal, zinc, none less than President Roosevelt and his advisers themselves are to blame for much of the shortages. Without giving American zinc producers the chance to protest, they lowered the zinc duty 20 per cent in favor of Canada, effective Jan. 1, 1939. When zinc producers finally heard of this action they brought forth a belated protest, stating that zinc prices would have to be cut 20 per cent also and that there would be no incentive to keep up marginal producing plants and explore for more ore, all working against our military resources. Their futile protest came true to the letter!

Moreover the zinc die casting process had developed into a great mass production outlet for zinc and made a heavier drain on that metal than during our first war.

Certainly, handling of prices of basic materials has been far superior in this era. Then they ran away like an escaped captive balloon. Copper reached 36 cents a pound in March, 1917; it has been held down to 12 cents today (except in very few instances where marginal producers were given subsidies. Open-hearth billets reached $95 per ton in June, 1917; they are frozen at $34 today. Basic pig iron sold at $54 in July, 1917, as against $24 today. In



the last analysis, of course, we lack perspective in determining how our war efforts today compare with those a quarter century ago.

Weighing heavily in the balance in favor of the present era is the cheapness of aluminum, the current price being 15 cents per pound. During the first war it reached 60 cents, but was reduced to 32 cents by Government decree on March 2, 1918, revised to 33 cents the following June 1.

Today aluminum might be considered cheaper than copper since because of greater lightness one gets equal or more bulk for his money than in copper. Public utility companies have often decided aluminum superior to copper for high tension lines, the less electrical conductivity being offset by greater lightness and need for fewer supporting towers.

Bombing from the skies has caused much rearrangement of our munitions plants. During the first war they were concentrated along our Atlantic Coast from Boston to Norfolk, Va. Today they are much more decentralized, with hundreds of plants on our Western prairies. Not only does this guard against bombings but tends to prevent congestion points in housing, labor supply and raw materials.

We have learned much from the first war, such as not to build a certain type of concrete ship which invariably failed.

Our plan for subcontracting of munitions manufacture is a distinct product of this war. Stationary "clinics" and traveling caravans displayed photos, blueprints and models of parts the prime contractor wanted to "sub." The only counterpart of caravans in the first war were "circuses" or freight trains loaded with guns, tanks and airplanes, which were more of ballyhoo nature than practical.

Civilian initiative has been outstanding in this era. Take York, Pa. It will go down in history for its initiative in "marrying" prime contractors to "subs" long before the Government got around to it.

We do know that our A.E.F. boys are an inch taller, more healthy, more resourceful and altogether better soldiers than their fathers in arms. And it is probable that these fathers as civilians, many at Washington, are doing a better job than their fathers in 1917.

Beginnings of Our War Planning

And now, for sake of the record, we go more into detail about Washington history to date, with briefer references to parallel events during the first war. Organized May 29, 1940, the day after the King of the Belgians surrrendered his 500,000-man army, and the day the Dunkirk retreat began, the Advisory Commission to the Council of National Defense has a nebulous place in the history of these desperate years. It stemmed from the National Defense Act of 1916, and was patterned after its predecessor of War I.

Industrial giants of the two world wars: Donald M. Nelson, head of the W.P.B., and Bernard M. Baruch, chairman, War Industries Board, World War I.

Edward R. Stettinius, Jr., who headed the National Defense Advisory Commission's Industrial Materials Division, made an outstanding contribution to the ultimate victory of the United Nations when he picked his staff more than 30 months ago. His deputy commissioner was tough-minded William L. Batt, industrial statesman of the first rank, who carried the materials responsibility through 20 months of hard fighting, and who is now No. 2 man of the nation's armament program as Donald Nelson's deputy. One of Mr. Stettinius' administrative chiefs was A. I. Henderson, later to be head of WPB's Materials Division, and now deputy director general of operations in charge of all materials and industry branches. His sights were remarkably high during the isolation and appeasement era when he was also priorities and export boss. A group of metallurgists and minerals executives and attorneys whom Mr. Stettinius "drafted" from industry are, for the most part, still on the job attempting to channel almost every material known to industry into armament plants.

None of these men knew that Japan would strike on December 7. None realized the magnitude of the armanent-program-to-be. But able technicians from industry were added through the various reorganizations, until today one of the most capable technical groups to be found in any national defense agency is working far into the nights for "Aleck" Henderson.

A comparison of foresight exercised during War I and the present emergency shows that men were working on the problem well in advance of the declaration of war on Dec. 8 (see Table I). Whereas all major organization of materials branches occurred *after* the declaration of World War I, April 7, 1917, all of our present materials branches were formed and were in operation nearly 2 yrs. *before* Pearl Harbor, differentials running as many as 999 days—as in the case of rubber.

Despite the dangers of comparing one emergency period with its predecessor a quarter of a century before, historical facts of considerable importance are shown in an objective analysis of the materials problems of these two eras, and what was done to solve them. Quantities of armament items, prices, priorities control, new facilities, conservation, and allocations play parts in both dramas of securing enough materials for armament production.

How We Started in 1916

By 1916, after more than a year of the European conflict overseas, it became apparent that there would be serious shortages of materials in the United States. The Naval Consulting Board appointed a committee to make a comprehensive study of 18,000 industrial plants, but the project was abandoned. Another report, made by the Kernan Committee appointed by Secretary of War Newton D. Baker, failed to achieve any valuable findings, largely because the questions did not call for definite answers.

The real effort started when President Wilson established the Council of National Defense (Aug. 29, 1916) which was not, however, formally organized until October 11, with the Secretary of War as chairman. On Feb. 28, 1917, the Council formed the Munitions Standards Board, headed by Frank A. Scott, and on July 28, 1917, the War Industries

TABLE I. Comparison of Dates of Organization of Materials Branches
World War I vs. World War II

Commodity	Number of Days Branch Formed *After* War Declaration April 7, 1917	Number of Days Branch Formed *Before* War Declaration December 8, 1941	Differential in Days	Branch Chief World War I	Branch Chief World War II
Aluminum and Magnesium	18	514	532	Pope Yeatman	A. H. Bunker
Chemicals	9	514	523	Charles McDowell L. L. Summers	
Iron and Steel	161	514	675	J. Leonard Replogle	Walter S. Towers A. D. Whiteside C. A. Adams Reese H. Taylor
Power and Communications	242	514	756	Fred Darlington	J. A. Krug (Power only)
Cork and Asbestos	389	514	903		Fred W. Gardner
Nickel		514		(Administered by Inco)	H. A. Rapelye
Tungsten, Molybdenum, etc.	334	514	848	H. W. Sanford	H. K. Masters E. K. Jenkes
Copper	151	514	665	Eugene Meyer, Jr.[1]	J. A. Church Harry O. King
Manganese, Chromite, Silicon Alloys, etc.	9	514	523	L. L. Summers	Andrew Leith
Tin and Lead	335	514	849	George N. Armsby I. H. Cornell	Erwin Vogelsang
Mica, Fluorspar	335	514	849	C. K. Leith	R. B. Ladoo
Mining		514			Wilbur A. Nelson
Zinc		514			David Ubelacker George C. Heikes

[1] Named chief, Non-Ferrous Section, WIB, October, 1917; chairman, War Finance Corp., March, 1918.

Board, destined to carry out the materials program for World War I, was created with Mr. Scott as chairman. Thus, nearly four months *after* the U. S. declared war on April 7 the materials and production directorate of World War I took shape. Bernard M. Baruch, later chairman of the Board, was at first Mr. Scott's Commissioner of Raw Materials. Within a few months the commodity sections began to take shape, but actual organization of branches, with delegated authority from WIB, lagged in many instances.

In general, the present serious materials shortages are incomparable to the tight spots of the last war. This is due to the increased size of armament units multiplied by the greater number of units required today.

Price Controls Then and Now

An important difference between the price controls operations of World War I and the present era is that during this emergency the price-fixing authority is now vested in the Office of Price Administration, an agency independent of OPM's successor, the War Production Board; whereas during the previous emergency price-fixing was administered by the War Industries Board itself through its various commodity branches. Another difference was that 25 yrs. ago the first problem WIB tackled was prices, but during the present emergency the problem of prices was met in most materials *after* some control had been exercised to conserve the commodities themselves.

Leon Henderson was appointed by the President as a Commissioner of the Advisory Commission to the Council for National Defense, in charge of Price Stabilization, in May, 1940. Then he was named administrator of the Office of Price Administration and Civilian Supply on April 11, 1941. Thus, granted some power—but not enough—he launched the "jaw bone" era and cajoled and threatened.

Two years and two months before Pearl Harbor Congress passed a bill making Emergency Plant Facilities Contracts "bankable." It was framed by Leon Henderson's Price Stabilization Division of the Advisory Commission to the Council of National Defense, and stands as a milestone in the labyrinth of national preparedness. The Civilian Supply Division was transferred to the Office of Production Management on Aug. 29, and the name of the price-fixing agency was shortened to Office of Price Administration with Mr. Henderson still in charge. Without the support of adequate legislation, and later with violent opposition to his coast-to-coast rationing appointees by vociferous congressmen, Mr. Henderson has done a magnificent job. Whatever may be the ultimate cost of this war, his efforts in fixing price ceilings will have reduced the total outlay by many millions of dollars to the taxpayer. If our nation is saved from inflation, much credit will go to Mr. Henderson.

During World War I price-fixing was done with the closest cooperation of the industries involved. Critics then feared that the conferences were far too cozy for the public good. Long before any formal agreements were concluded, and Presidential orders were issued establishing materials prices to the gov-

Production chiefs visit Ford Willow Run plant. Left to right: W. A. Harriman, C. E. Sorensen, Donald M. Nelson, Henry Ford, Oliver Lyttleton (British Minister of Production), W. S. Robinson (Australia), W. S. Kanzler, Edsel Ford.

ernment, Bernard B. Baruch and his able non-ferrous chief, Eugene Meyer, Jr., had done a great deal of spade work. This early period contrasted sharply with the early days of Mr. Henderson's activities, when industrial leaders were more than once surprised by the tone of voice of Mr. Henderson and his colleagues, and a bit shocked at the "youse guys" attitude some of them used while presiding in the seat of government. Mr. Henderson's associates cannot be charged with a shortage of book-larnin', although when primed with the indignation of the have-nots-now-in-power, some of them tended to be strident.

An important difference between the price-fixing of the two periods was that during War I, price controls affected the refined basic material, and in some cases its raw materials; whereas during the present emergency the program has been extended to manufactured goods at retail prices, rents in defense areas, some services, etc. Mr. Henderson's simple reasoning that wages and farm prices—as well as corporate profits—had a share in the anti-inflation strategy caused consternation among pressure groups such as labor, farm, and lesser blocs. Price-fixing became a political shibboleth and the whole effort has been thrown into the bitter arena of politics—and that, unfortunately, on the eve of a congressional election. OPA's rationing powers have added fuel to the political flame, while Mr. Henderson has been trying to induce congress to plug up some holes in the Emergency Price Control Act of 1942, signed by the President on Jan. 30, 1942.

OPA's ceiling technique during the present emergency has already proved to be far better than the "bulk line" pricing employed during War I.

Planning all-out production: William H. Harrison, director of war production, and Donald M. Nelson.

Materials price-fixing dates of World War II compared with War I are shown in Table III. "Differentials in Days" (last column) attempts to show that, upon the basis of dates orders were issued, the present program was well ahead of World War I. The first maximum price regulation issued during the present war was on Feb. 17, 1941, covering second hand machine tools.

TABLE II. Material Prices—Annual Averages in Dollars

Metal	1900	1914	1915	1916	1917 High	1917 Price Fixed by W.I.B.	1917 Low	1917 Average	1918 High	1918 Price Fixed by W.I.B.	1918 Low	1918 Average	1941	1942
Aluminum	0.33	0.20	0.28	0.415	0.6077	0.38[1]	0.3640	0.5159	0.33	0.33[2]	0.33	0.33	0.17	0.15
Antimony	0.108	0.0853	0.0595	0.058	0.346		0.136	0.207	0.1475		0.0762	0.1255	0.15	0.16
Copper (Lake, N.Y.)	0.1617	0.136	0.1764	0.2817	0.3575	0.235[3]	0.235	0.2918	0.26	0.235[3]	0.235	0.247	0.1179	0.12
Iron & Steel														
Pig (composite ton)	17.82	13.52	14.15	20.31	60.00	33.00[4]	39.99		38.00	33.00[4]		34.38	23.51	23.61
Bars (lb.)	0.0161	0.0148	0.0131	0.0248	0.2213	0.029[4]		0.0349		0.029[4]		0.028	0.0214	0.0214
Shapes (lb.)	0.0191	0.0154	0.0130	0.0250	0.0631	0.03[4]		0.0366		0.03[4]		0.0299	0.021	0.021
Plates (lb.)	0.0155	0.0114	0.0129	0.0282	0.2200	0.0325[4]		0.0521		0.0325[4]		0.0396	0.030	0.028
Billets (gross ton)	25.15	20.08	22.51	44.23	95.00	47.50[4]	47.06[4]	71.15		47.06[4]		47.30	34.00	34.00
Steel (composite)	2.26	1.52	1.63	2.80				4.46				3.79	2.51	2.49
Lead (lb., N.Y.)	0.0437	0.0367	0.0467	0.0679	0.1225	0.0775[5]	0.055	0.087	0.0805	0.0805[6]	0.0805	0.0805	0.0579	0.065
Platinum (troy oz.)		45.14	47.13	83.40	105.00		87.00	102.00	108.00	105.00[7]			36.00	36.00
Tin (lb., N.Y.)	0.299	0.357	0.3864	0.4348	0.8712		0.425	0.6166	1.110	0.725[8]	0.70	0.868	0.5201	0.571
Zinc (slab, N.Y.)	0.044	0.053	0.1444	0.1375	0.1105		0.0767	0.0911	0.0985	0.12[9]	0.0682	0.0831	0.0747	0.073
Composite Metal		8.555	12.542	16.826				17.643				16.654	9.401	9.323

[1] Sept. 1, 1917, for government purchases. Speculation and forward buying kept the market in violent upsets, but Alcoa furnished U. S. requirements at agreed-to prices throughout the war.

[2] June 1, 1918, to March 1, 1919, to all U. S. users, and wage decreases were prohibited by Presidential edict.

[3] Sept. 14, 1917, as per industry-government agreement.

[4] Oct. 11, 1917, Steel Schedule. Revised schedule followed on Nov. 11, and several minor amendments were issued. Speculative and foreign buying, however, prevented market stabilization.

[5] June 18, 1917, Government Schedule. Note that this schedule was higher than the lows of 1917 which followed.

[6] June 14, 1918, Schedule. Agreed to by the government because of necessary wage increases to keep up production following the last quarter, 1917, and first quarter, 1918, gluts.

[7] May 1, 1918 Schedule.

[8] Dec. 1, 1918, later adjusted to 69.46876c.

[9] Feb. 13, 1918. Agreement: East St. Louis Grade A; plates 14c, sheet, 15c.

TABLE III. Dates on Which Materials Prices Were Fixed

Material	World War II Date Effective	Price Schedule No.	Days *Before* War Declared	World War I Date Effective	Days *After* War Declared	Differential in Days
Aluminum scrap & secondary ingot	March 24, 1941	2	259	April 25, 1917	18	277
Iron & steel scrap	April 3, 1941	4	249	(none)		
Zinc scrap & secondary slab	April 9, 1941	3	253	Feb. 13, 1918	312	565
Iron & Steel	April 17, 1941	6	235	Sept. 24, 1917	170	405
Nickel scrap	June 2, 1941	8	189	(none)		
Pig iron	June 24, 1941	10	167	Sept. 24, 1917	170	343
Brass mill scrap	July 22, 1941	12	139	(none)		
Copper	Aug. 12, 1941	15	118	Sept. 21, 1917	167	285
Tin, pig	Aug. 16, 1941	17	114	(post-war price settlement)		
Copper and alloy scrap	Aug. 19, 1941	20	111	(none)		
Steel castings	Nov. 15, 1941	41	23	(none)		

Note: All of the above orders have been amended. Since the declaration of War, December 8, 1941, a number of Price Schedules have been issued by the Office of Price Administration on other metals, and on a large list of metal products.

The General Maximum Price Regulation, dated April 28, 1942, put about one-half of the nation's entire wholesale price structure under ceilings.

Priorities Problems of Two Wars

Priorities invoked by the War Industries Board during World War I apparently sufficed, although there were desperate days of materials shortages when whole sections of the nation's war industries were shut down.

One of the most devastating criticisms of the materials controls during the present emergency lies in the breakdown of the present system, based on the World War I experience, and the failure of WPB to alleviate the "shortages" in face of actual plenty in many instances.

A pungent comment on "priorities inflation" was made by W. L. Batt, who told a press conference that WPB had overdrawn at the bank. It has handed out more priorities for critical raw materials than there are materials available. During the intervening six months this has become an habitual performance.

In July, 1941, under the OPM, the old priorities system first became seriously inflated. To obtain materials it became necessary to have ratings of A-10, A-5, and finally A-2 or higher, which ratings originally had been preserved for the military services. Priorities became meaningless and the priorities system broke down. In the resulting shake-up the old Supplies, Priorities and Allocations Board was formed.

Since then OPM and WPB established an allocations method to specifically direct deliveries of critical raw materials to fabricators of importance to the defense program. Inasmuch as the production cycle in this country is an extended one, the allocations, in most instances, did not reach through to the assistance of the fabricators of the end product. The allocations applied only to the first transfer of raw materials in the first stage of production. The fabricator of the end product, in many instances and for many items, was still dependent upon his priority rating.

Inflation of ratings has still continued. The highest is now AAA. The lowest rating that has any effectiveness in a scarce commodity is A-1-A. Furthermore, any specific allocations of material, which in effect are orders with the force of law, require the distribution of great quantities of material regardless of any preference rating. As these special allocations have grown in number, the material to be distributed pursuant to preference ratings has necessarily declined—thus rendering ratings of less and less value.

The preference rating system which we might otherwise term "qualitative distribution," has been in a large part responsible for the maldistribution of our available supply of raw materials. Manufacturers with high preference ratings are inclined to over-order and over-use the privilege of first call on available supplies of critical materials. The new WPB Quota Allocation System has been announced as a steel allocation plan using a certificate system. In some respects it is similar to the British and German schemes.

To date the simplest and best method devised is that of the Germans and British. They issue coupons, license over authorizations, and these authorizations are passed from the materials consumer to the materials suppliers. In this way a limited quantity of material is guaranteed to every user. The distribution is on a *quantitative* rather than a *qualitative* basis. It is a plan that has been followed by England since July, 1940, and by Germany for a still longer period.

Plant Expansions

New materials facilities were first recommended by the Industrial Materials Commission of the National Defense Advisory Commission to help win World War II. Being an advisory group, it was not until after the Office of Production Management was established that any actual attempt was made to expand domestic productive capacity of materials. More than $1,000,000,000 was spent by private capital for plant expansion during that early period of confusion when the government was trying to formulate a program. Announcements of contracts that never materialized, recommendations for doubling and tripling the various programs, and counter recommendations for reducing the outlay kept the new materials facilities subject in a state of unhappy flux. But industry's achievement in beginning new facilities with private capital has already proved to be a factor of major inportance in our nation's struggle.

Conservation Plans Compared

Conservation's high priest was Robert E. McConnell in the earlier days of OPM. A consulting mining engineer of standing, he at once enlisted the services of many conservation stalwarts from industry. Paradoxically, the metallurgical experts whom Mr. McConnell secured from industry for the duration were men who for years had been selling industry on the idea of using more nickel, zinc, aluminum, chromium, and the whole list of now critical materials. They immediately threw their own thinking into reverse. They set out to evangelize the most profligate of nations to seek substitutes for these now-critical materials.

A whole series of new national emergency (NE) chemical compositions was developed by industry metallurgists to save scarce materials. By then, however, most of the consumer durable goods manufacturers had been shut down by curtailment and conservation orders, and the No. 1 problem was to sell industry's No. 1 customer, the Army and Navy, on changing their specifications for armaments in an effort to conserve the more critical materials. The Army and Navy tacitly agreed to changes provided the end product stood up under ballistic and other service tests. This introduction into military thinking of a sound engineering problem was an achievement of the first order. To Mr. McConnell and his colleagues, including Harvey A. Anderson and E. J. Hergenroether, goes the credit.

World War I conservation chief was Arch W. Shaw, chairman of the Commercial Economy Board, formed on March 24, 1917, a fortnight before the U. S. declared war against Germany. This became the Conservation Division of WIB on May 8, 1918, with Mr. Shaw, a Chicago business-paper and book publisher, still in charge. The philosophy of the Division was to achieve whatever economies in business practices as were possible without upsetting industries. He successfully fought against a plan, strongly supported, to eliminate non-essential industries altogether. His scheme was to reduce non-essential uses of labor, materials, capital and equipment in all business.

Simplification, the reduction of sizes, types, and styles, was the chief effort of the Conservation Division in War I. Although conservation was loudly discussed from the days of the inception of the present emergency, nothing of importance has been achieved since Mr. McConnell's tenure, and the appointment of Lessing Rosenwald more than a year ago, until a few months back. That was the announcement of the National Emergency (NE) steel and non-ferrous specifications. These were developed by industry's metallurgists and engineers who had been working on these problems for years as members of industry and engineering society committees. Simplification only recently was put under the administration of an able executive, Howard Coonly, industrialist, who saw service as vice chairman of the War Shipping Board during World War I, and who served with distinction as president of the American Standards Association a few years ago. Salvage programs, until a couple of months ago, were mostly publicity campaigns, and small business men have been groping for the "know how." Recently Mr. Rosenwald and his associates began to understand that practical reclamation requires engineered planning, not speeches, and a committee of realists are at last working on the problem.

Allocations to Control Materials Flow

Allocations, as a method to control the flow of materials, was first seen in some of the Materials Conservation (M) Orders. Four days before Pearl Harbor the Production Requirements Plan was announced by OPM's Division of Priorities. Not until June 18, 1942, did the plan become an official order, though several thousand companies had been operating under its provisions for several months voluntarily. The PRP at last put materials supply and demand on a bookkeeping basis. But the PRP cannot perform the miracle expected of it by WPB executives. Called WPB's "white hope" by some Government spokesmen, it is essentially simply an inventory mechanism. The allocation certificate incorporated in the zinc order for example, insures that the manufacturer gets no more zinc than the specified amount, but does not insure his getting any at all.

Observers of the Washington scene have been amazed at the lack of interest on the part of OPM, SPAB, and WPB in the British method of materials allocations. Desperate materials shortages had already thrown whole British industries out of work, and that nation abandoned its priorities system before ours was put into effect.

Although full details of the British system have always been available to WPB and its predecessors, the U. S. priorities system was clung to with desperate hope even after it had proved to be ineffective. The Steel Conservation Order (May 23, 1942) proved conclusively that the priorities system had broken down. Although it was issued to put the steel industry under complete Government control, it has failed to offer any adequate remedy for shortages of steel for armament manufacturers. Reason No. 1: Scheduling was not provided for.

Yet on November 11, 1941, Eugene G. Grace, president of Bethlehem Steel Co., urged Government officials to set up the equivalent of a steel company's order department to schedule production and shipment of steel to arms factories. The occasion was an all-day meeting, presided over by A. D. Whiteside, then chief of the Iron and Steel Branch, OPM. It was addressed by more than a score of Government speakers, including William S. Knudsen, then director general, OPM, Donald M. Nelson, executive director, SPAB, and others in high positions. Most of the speakers expounded weird theories to the 200-odd steel executives present. It was all topsy turvy. The talkers should have remained silent and listened to what the other group had to say.

The WPB system's chief deficiencies are highlighted when a simple commodity such as steel is considered. Steel often passes through many stages—from ingots to bars, to rods, to bolts and nuts, to sub-assemblies, and finally to assembled products. An allocation of ingots or bars to rod makers, or rods to screw or bolt makers gives no assurance that a required number of specific armament products will be forthcoming within a given period of time, if the fabricators of the end products must depend solely on priority ratings to obtain their sub-assemblies, parts or raw materials. Priorities can place first things first, but it gives no assurance that a balanced program will result. Allocating raw material at the first step of the productive process is of some assistance, but it is necessary to follow the material through to the end product. To insure a smooth flow of material it is necessary to start with the end product and work back, scheduling the flow of material and taking steps to assure that the material required at each step of the process will be present when needed.

The job of scheduling the flow of material is necessarily that of a production engineer working with a traffic expert. The work of scheduling and making available adequate material deliveries in peacetime is, by comparison, simple. But it was worked out in detail by the English over 2 yrs. ago and by the Germans before that. Both have patterned their schemes after industry procedures, however.

Any manufacturer knows how much material he needs and when he needs it. Licenses or authorizations permitting him to receive this material during the scheduled production period should be issued to him, preferably by the Government agency most familiar with the needs of the producer. In the case of a prime Government contractor this agency is the contracting authority. The authorization should be an established one operating in much the same manner as a priority rating, except that any amount of material that may be acquired under it is limited in amount and reported to the Government agency controlling that material, i. e., the materials branches of WPB. The authority can be extended to subcontractors and to sub-subcontractors to the degree and extent necessary.

In England and Germany it carries the code letters of the government agency making the authorization and the numbers of the contract for which it is issued. Raw materials suppliers report the lump amounts of materials used during any calendar quarter by any Government agency. In this manner it can be quickly seen whether any agency is issued authorizations for more material than it can properly dispense pursuant to the board determinations of a central materials committee, or whether individual authorizations may be used to excess. Exemptions might be permitted to small users of raw material who may buy from dealers who in turn obtain material pursuant to a special permit of the Director General for Operations, WPB.

Steel in the Two Wars

The steel background of World War I is similar to that of War II in a number of respects. In both cases:

1. Defense activities followed periods of depressions during which the industry had been producing only a fraction of its rated capacity. Serious financial reverses had been faced in both periods,

2. Early estimated requirements were far too low, and had to be multiplied from time to time

The present experience has been more confused than that of War I by these unhappy factors:

1. Management: The administration's suspicion of "big business" prevented the full use of steel (and other) managerial experience. Walter S. Tower, president of the Iron and Steel Institute, was the group executive of the Iron and Steel group of Commissioner Stettinius' Industrial Materials Department, Advisory Commission to the Council of National Defense, back in July, 1940. Capitol Hill quickly raised a howl about dollar-a-year men, especially trade association executives—and OPM got cold feet, retired Mr. Tower and William S. Knudsen, named Mr. Whiteside, president of Dun & Bradstreet, Inc., to the post of chief of the Iron and Steel Branch. Eighteen months later he was succeeded by C. E. Adams, president, Air Reduction Sales Co., and one of Mr. Stettinius's assistants in the NBAC days, and on May 25, 1942, Reese H. Taylor, president of the Union Oil Co. of California and formerly president of the Consolidated Steel Co., became head of the branch. He resigned on Aug. 28;

2 Confusion caused by such reports as the two submitted by Gano Dunn, an eminent consulting engineer but who like

nearly every one else did not anticipate the dastardly treachery of the Japs;

3. Delay in obtaining from the Army and Navy their respective requirements. Army and Navy men were said to be reluctant to estimate, as requirements were constantly increasing;

4. Navy Lend-Lease commitments for steel, which also have been increased periodically.

The first method of allocating iron and steel was patterned by General Preference Order M-17 (Aug. 1, 1941) which was one of the first orders to completely allocate any material. Provisions were made for allocation, but there was no implementing mechanism to enforce allocations. Since there are relatively few users of pig iron, the problem was not as complicated as in other materials which were used by many fabricators. In the case of pig iron, the metal was allocated every month, and no commitment for a period of more than a month was recognized.

In the allocation of steel, warehousing controls were found to be essential as much of the total tonnages used by smaller American manufacturers are supplied through this channel. There are over 15,000 such warehouses in the country. "Controls" of warehouse stocks were begun late in 1940, but these didn't help much because there was no scheduling system for materials.

To date the Iron and Steel Branch cannot effectively schedule raw materials through the mills and to factories; or conversely from requirements through the various stages and back to the mines, as recommended by Mr. Grace nearly a year ago. The vast amount of paper work required to fill in the numerous forms has been reduced from time to time, but paper work will not solve scheduling: Only hard-headed men who have scheduled materials in industry can solve this major problem of flow of materials.

Shortages will continue to be serious, and thousands of war workers will be laid off because of lack of steel—chiefly because of lack of business-like handling of the materials supplies, rather than because of actual shortages. "Black markets" will continue to exist as long as manufacturers of armaments persist in meeting the production schedules set by the Army, Navy and other procurement agencies. The materials situation is just that serious today.

Increase in Capacity

Current rated capacity of U. S. steel producers is 88,569,970 tons a year (1942) and WPB has finally recommended a program to increase this more than 10 per cent, to about 98,279,970 by the middle of 1943. Marginal iron ores in New York, New Jersey, Texas, California, and Utah are now being tapped.

The 7,692,000-ton increase in open-hearth steel capacity will be obtained by:

New furnaces to provide 4,891,000 tons;

Hot metal from blast furnaces, instead of cold scrap, will account for 2,163,000 tons, and

Restoring and enlarging old furnaces will bring in 638,000 tons.

About 5,165,000 tons of the total increase in ingot capacity will be completed this year and an additional 4,545,000 tons brought into production in the first half of 1943, a total of 8,710,000 tons.

A corresponding increase in pig-iron capacity has been approved to make up for the reduced amount of purchased scrap expected next year and thereafter.

The increase in pig iron capacity is to be about 10,945,000 tons. This year is to see the completion of 6,349,000 tons of this total, with the other 4,596,000 in 1943. Completion of the pig iron program will make a total of 70,351,410 tons available, with 9,500,000 tons necessary for merchant iron and ferroalloys. This leaves 60,851,410 tons available for steel-making. The cost of this expansion is estimated at $1,500,000,000, of which industry is undertaking

The War Metallurgy Committee. Seated: A. E. Schuh, Lieut. B. S. Old, Zay Jeffries, C. E. Williams, Louis Jordan, L. S. Strickland, John D. Sullivan. Standing: Howard Cross, C. H. Lorig, R. K. Waring, A. B. Kinzel, C. S. Smith, H. W. Gillett, G. S. Mikhalapov, H. W. Russell, V. H. Schnee.

a total of $500,000,000 and the Government the balance.

Early estimates of the war use of steel in the previous war was something like 17 per cent of the 1917 annual capacity of 35,000,000 tons. However, so great had been the expansion of the armament program that by mid-1918, 100 per cent "control" had been effected over the steel industry by the War Industries Board. Then, as now, "control" did not mean physical control of the flow of steel from mills to armament factories. Because of large British and French purchases of steel, pig iron capacity had been increased 83 per cent during 1915 and 1916. As early as 1915 rail mills had been converted to the production of shrapnel bars, and a number of other types of mills went all-out to supply armament shapes, plates, bars, etc. Then, as now, most of the early expansion was paid from depleted reserves of steel companies.

Prices had climbed (average weighted of all steel products) to 240 per cent of the pre-war levels by the end of 1916. Wide publicity, including statements by President Wilson, set the stage for price control. Prices were nailed down to a new schedule on September 27, 1917, 170 days following the declaration of war. (See Table II)

Rationing was not applied for steel products until July 22, 1918, (Circular No. 5), or 471 days after the declaration of war, and 112 days before the Armistice.

Aluminum More Vital in War II

The bulk of aluminum used in armaments is for aircraft, aircraft engines and accessories. Up to the outbreak of the present war, the bulk of aluminum was being used in civilian industries. A series of curtailments provided a "kitty" for aircraft production, but consternation was let loose by the President when he announced the nation's armament goals for aircraft on Jan. 6, 1942. Without changing the 60,000-airplanes-for-1942 figure, emphasis was later put on heavy bombers which threw estimates of aluminum requirements out of the window, and several succeeding "guesses" have been torn up since.

Because the Aluminum Co. of America was then the only producer of the metal in the country, many Government officials suspected the corporation of the worst possible motives in the early OPM days. Some of the economists on the Government payroll freely expressed their doubts as to the "loyalty" of the corporation's management. The germ of this idea was fed by a few uncorrelated statistics and a mass of misinformation mixed with strong "big-business-be-damned" emotions.

The result of this gluttony for witch-hunting was a perverted point of view which went far to prevent full confidence in the only men in the United States who had been trained to understand the problem.

The first of nearly 200 general preference orders on materials was issued on aluminum (effective March 22, 1941). Its supplement, issued the same day, provided that producers and fabricators should give preference to defense orders. As defense demands for aluminum increased during the latter part of 1941, outrunning production and prospective output of the metal, successively lower percentages were permitted to non-defense manufacturers, until today almost the whole output of our supplies is going into airplanes and a few minor armament items.

The cost of new capacity, completed and building, will run about $568,000,000, with private industry (Alcoa and Reynolds Metals Co.) spending about $85,000,000 of the total. Part of this expansion is for primary production of aluminum (from domestic and imported bauxite and from domestic alumina deposits), and part for fabricating plants.

Copper Key Metal in Wars

On Nov. 7, 1940, 396 days *before* Pearl Harbor, the National Defense Commission recommended that the Metals Reserve Co. buy foreign copper for domestic use. OPM took the allocation of copper from the Metals Reserve Corp. on June 1, 1941, 189 days before Pearl Harbor. From then on copper kept in the headlines for months. It was the basic reason cited for the curtailment and then cessation of the automobile, refrigerator, and scores of smaller industries. Tightened by M-9-a (Aug. 2, 1941) when only the armed services and "essential civilian" were permitted the use of the metal, it was followed by M-9-b (Sept. 30, 1941) controlling the movement of scrap. Then on Oct. 15, 1941, M-9-c was issued, reducing the use of copper in the manufacture of about 100 items, and prohibiting its use after Jan. 1, 1942; reducing the rate of manufacture of all other items containing copper; and listing general exceptions for the Army, Navy, Lend-Lease, and health and safety products considered to be essential.

Thus, by virtue of orders, copper came under "control" before Pearl Harbor under this scheme:

1. Allocation of refined production, which has been effectively administered,
2. Control of fabricated products by the preference rating system. This has been less effectively administered, due to the large number of manufacturers involved, and
3. Control of scrap movement. This is the weakest link in the chain, largely due to the failure of OPM and then WPB to instruct small users *how* to segregate and collect scrap.

The goal for scrap is 300,000 tons a year. Instead of arranging for the copper industry to collect manufactured items on dealers' shelves and warehouses for re-melting, a new agency was formed to buy in these items—the Copper Recovery Corp., a subsidiary of the Reconstruction Finance Corp.

Payday for Dollar-a-Year Men. E. R. Stettinius hands out pay checks to a group of his associates.

Shortages will be with us until the end of the war, despite the excellent techniques for making steel shell cases and substituting other materials for copper and brass arms items. The natural tendency for government agencies is to claim credit for every development in armaments, but the fact is that most basic research was done, voluntarily and often even without Government moral support, by the production engineers and metallurgists of industry. Today, however, both the Army and the Navy are up in the front of the conservation and substitution parade.

Here is a brief picture of copper shortages recently issued by WPB:

	1942 TONS
SUPPLY	
Domestic production	1,100,000
Imports (Latin America)	500,000
Other imports (Canada, Mexico)	100,000
Secondary copper	100,000
Total	1,800,000
DEMAND	
All military (including foreign)	1,000,000
Essential civilian	400,000
Other civilian	1,170,000
Total	2,570,000
SHORTAGE	770,000

Since these tables were released, military requirements have been increased considerably, some increases have been made in production over the above estimates, and the "other civilian" tonnage has been sharply reduced.

Copper Capacity

The government has spent and committed itself for a copper expansion program totaling $180,000,000, and private capital about $40,000,000, to meet the demands of the present emergency. About 98.5 per cent of the U. S. copper production comes from 15 mines, and the remaining 15 per cent comes from 270-odd. Much of the government's program is in the low-grade ore areas. To this will be added a good many millions of dollars for "bounties" to encourage production in the low-grade ore fields.

Eighteen days before our entry into War I on April 7, 1917, the Advisory Commission of the Council of National Defense reached an understanding with U. S. producers to sell 45,510,000 lbs. of copper to the Army and Navy at 16.6739c per lb. The open market price at the time was 35.74c. This low figure was adjusted to 23.5c on Sept. 21, 1917, and increased to 26c on July 2, 1918, after a study had been made of actual costs of copper production. Wage increases made then, as now, large gaping holes in price ceilings.

Mr. Meyer, now publisher of the Washington *Post,* was one of the best informed investment bankers on copper and became Mr. Baruch's non-ferrous chief in October, 1917, more than 170 days following the U. S. declaration of war. Pope Yeatman, one of the country's outstanding mining engineers, succeeded Mr. Meyer in March, 1918, when the former was appointed chairman of the War Finance Corp.

Zinc in the Two Wars

By early 1941 zinc producers were prorating supplies to their customers but it was not until March 7 that each producer was asked to set aside 5 per cent of his production, beginning April 1, for Government allocation. This was raised to 17 per cent of the March production to be set aside for May, and 22 per cent of the April production for June, and 29 per cent of the August production for December. Zinc oxide and zinc dust, included in earlier orders for setting aside certain percentages, became more plentiful and were excluded from later orders. On June 10, 1941, M-11 was issued, putting zinc under mandatory priority control. Amendments tightening the controls were issued on June 28 and Oct. 16.

As with copper, industry has done a remarkable job in suggesting substitutes for zinc products. Besides the projected zinc tonnage for brass cartridge shells, a large tonnage of other zinc die-cast products has been shifted to steel—in some cases strip and others formed wire doing an adequate job. Many of these substitutes came through ballistic and service tests by the Army and Navy with flying colors.

Zinc was never a serious problem for the War Industries Board during World War I. But as in the case of most metals, the question of price concerned WIB more than supply at the beginning. As against the prevailing price of 22.5c per lb. for sheet, Edgar Palmer, president of New Jersey Zinc Co., agreed to sell to the Government any quantity at 12c. Zinc was substituted for tin, lead, aluminum, and nickel when these metals became tight. Allocations were handled through a committee of the mining industry, and the job was done well.

Everett Morss, a Boston manufacturer of brass products, was named chief of the WIB Brass Section on April 6, 1918, a year after we entered the war. The only important shortage of brass at that time was in tubing, resulting from lack of capacity and copper shortages. As the material became tighter, shipments were banned except for holders of priority permits on and after July 10 (Order, June 26, 1918). Formal price fixing of brass was not resorted to until Feb. 13, 1918—312 days after the nation joined her allies.

During the present emergency the supply and demand pattern of zinc differs from all other critical materials, inasmuch as it was scarce in the early period, became less critical while other materials were tightening up, and now it is becoming scarce again. Substitution of other metals for zinc was one of the toughest problems of the Industrial Materials Division of NDAC because a large civilian use of the metal has been stimulated throughout many U. S. industries by the development of zinc die-cast equipment. As a result, the Army and Navy specifications had begun to rely heavily upon this light, non-corrosive metal because it could be manufactured at a relatively small cost of man-hours and finishing equipment.

J. A. Church first undertook the management of the zinc problem in July, 1940, under Mr. Stettinius. After months of service, Mr. Church was succeeded by David Ubelacker, a consulting engineer, who had been in Government service since November, 1940. On May 29 of this year George C. Heikes was appointed chief of the Zinc Branch, which had by then been separated from the Copper Branch. Mr. Heikes had been a mining engineer and geologist for the National Lead Co., and first saw Government service in November, 1940, having served under Mr. Ubelacker, who was recently recalled by his firm, Ford, Bacon & Davis.

These men, their associates, and industry had gone all-out in their efforts to conserve zinc. Intensive development of zinc deposits had increased the supplies over earlier estimates. But the guardians of the zinc supply of the nation have the lid nailed down on

unnecessary uses of the metal, believing that demands will be increased before they are lessened.

The zinc picture is further complicated by the fact that the over-all ore outlook is none too bright. It is a question how long zinc output can be maintained at present levels unless new ore bodies of considerable extent are discovered.

Tin a Problem in the Second War

Sources of America's tin supply were seriously threatened when Great Britain declared war on Germany, Sept. 3, 1939. With a U. S. consumption of about 110,000 tons in 1941, only 44 tons were produced in this country—mostly from Alaskan ores. When Singapore and the Netherlands East Indies fell to Japan, 90 per cent of the normal U. S. supply was shut off. In March, 1941, the U. S. Bureau of Mines reported no hope from the negligible domestic ores.

In July, 1940, Mr. Stettinius appointed Erwin Vogelsang, eminent merchant in non-ferrous metals, as head of the tin branch of the Division of Industrial Materials, NDAC. Long before Pearl Harbor, he started the successful move to build a tin smelter in the United States. This is now operating successfully at Texas City, Texas. It was designed to produce about 18,000 tons of tin from ores imported from Bolivia, and it is now being increased to 74,000 tons.

Because of the stockpile, accumulated after Sept. 3, 1939, and the new tin smelter, reductions in amounts used for food cans, curtailments in many other industrial uses, and the willingness of the Navy and Army to specify substitutes for the metal, the tin situation has eased up. But because of the inadequacy of supplies available to the United Nations, and the long, hazardous shipping routes for imported ore, WPB will keep the lid nailed down.

World War I tin control was vested in George N. Armsby, a New York financier who had had experience with tin as vice-president of the California Packing Co. He was appointed chief of the Tin Section, WIB, on March 6, 1918, 11 months *after* our entry into the war. Long haul shipping lanes for ore were then relatively safe, and plenty of refining capacity was available in Malaya, and the Netherlands East Indies. But refineries in Belgium, England, and France were in the zone of the U-boat menace.

Production Outran Schedules

Despite all the confusions in this era at Washington: Expansions of materials capacity were undertaken by private capital *before* the larger Government programs were approved;

Production of materials ran well ahead of schedules;

Production of armaments not only began ahead of schedule, but the rates of increase outran the best estimates that could be made during the blueprint era; and

Redesign of arms by the engineers of industry, when permitted to do so by the Army and Navy, always reduced the amount of scarce materials required, and always cut deeply into estimated manhours for the parts.

As evidence, a check of the public announcements and speeches made by the Army, Navy, and other Government officials shows that praise of American industry is generally couched in phrases similar to those used in citations of valor on the field of battle. In almost every industrial center of the United States one sees the Army, Navy and Army-Navy pennants flying over factories and plants of metals suppliers.

This is only what American industry expected to do, all along. Only the economic theorists who believed that the Government should have "taken over big business"—whatever that may mean—are surprised.

In general, confusion in priorities and lack of any workable mechanism to keep the flow of metals going where they should go will cause more material shortages than lack of plant capacity. But the time is at hand when *actual* shortages in some of the more critical materials will be a fact, and our country will be forced from its profligate use of almost every commodity to a genuine wartime economy in men, materials, machines, and management.

The National Emergency Steels

Hindsight may ultimately reveal that the major engineering achievement of this last year in the metal industries was "metallurgical" in nature—the development of a series of very-low-alloy machinery steels that could successfully be substituted on a large scale for the heavily alloyed "S.A.E." steels widely used heretofore in the automotive, aircraft, machinery and other fields. Their creation not only makes our alloy supply go that much further, but permits the full utilization as alloying agents of the "residual impurity" content of the ordinary scrap used in steelmaking. The technical aspects—the new concept of calculating properties and hardenability from exact composition, and the astonishing hardenabilities of these steels despite their low-alloy content—are matched in interest by the inspiring cooperative work of the large group of American metallurgical engineers that made the steels possible. Mr. Parker, up to his neck in this development since its inception, is admirably fitted to tell its story as an engineering achievement. —*The Editors*

by CHARLES M. PARKER

Secretary, General Technical Committee, American Iron and Steel Institute, New York

As our war effort expands and greater and greater tasks are assumed by American industry in aiding our Allies and in building up our own armed strength, the quantity of alloy steels which will be required to build the weapons which fly, float and shoot will expand even more rapidly than it has up to now. Unfortunately, the quantity of alloying elements available to us has not expanded to the same degree—in some cases it has diminished—and some sources which are now open to us may soon be closed—but only temporarily.

However, we must provide for that temporary closure, if it happens, and we must make 18,000,000 tons of alloy steel in 1943 with a quantity of alloying element which, a year ago, we would have considered inadequate for only about half that amount.

Some weeks before the nickel shortage became generally known, the Committee on Manufacturing Problems of the American Iron and Steel Institute requested the Technical Committee on Alloy Steel to prepare a factual schedule of possible alternates for nickel steels. The results of the Committee's work have been published under the title, "Possible Substitutes for Nickel Steels." That work enjoyed a unique welcome in the field of material substitution, providing as it did sound technical recommendations for substitute steels containing little or no nickel.

In recommending alternates for nickel steels, chromium and molybdenum were drawn on freely. Partly as a result of that, partly as a result of the reduction in sources of supply for chromium, and partly as the result of a shift which had started well before the war, chromium is now restricted in the same manner as nickel. Accordingly, the Technical Committee on Alloy Steel developed alternates for standard chromium and nickel-chromium steels which are now known as the "National Emergency (NE) 8000 Series Steels" and which were published by the Institute under the title, "Possible Alternates for Nickel, Chromium and Chromium-Nickel Constructional Alloy Steels."

How the Steels Were Designed

The National Emergency steels were designed by a representative group of able metallurgists recruited from the Technical Committee on Alloy Steel of American Iron and Steel Institute, the Iron and Steel Division of the Society of Automotive Engineers, and representatives of producers of alloying elements to assist the many industries of the United States and its Allies' to achieve a supreme war effort. The steels were designed not to "save" alloying elements in the chipmunk sense of the word, but to make maximum use of alloying elements in order to make

possible the production of more tons of steel having characteristics superior to simple carbon steels with the same amount of alloying elements as would normally have been used to produce a far lesser tonnage.

In devising alternates for nickel, chromium and nickel-chromium constructional alloy steels, a plan of action was laid out, taking into consideration not only the immediate shortages of nickel and chromium, but looking into the future a bit to see what the scrap situation might be in an effort to take maximum advantage of any opportunities that might become apparent.

It was well known that the residual contents of nickel, chromium and molybdenum were rising in both recycled and purchased scrap and, accordingly, advantage was taken of that fact in the NE 8600, 8700, 8800 and 8900 series.

The experience of one large producer of alloy steels in melting nickel steel heats is summarized in Fig. 1. It is evident that in the field of low nickel steels, whether of simple or complex composition, more than 90 per cent of the nickel called for by specification ranges is being recovered from steel scrap.

The charts, Figs. 2, 3 and 4, show the incidence of molybdenum in nickel-chromium steels, of nickel in chromium-molybdenum steels, and of chromium in nickel-molybdenum steels.

By combining the incidental or recoverable nickel, chromium and molybdenum from scrap with small quantities of virgin metals or ferroalloys, it was apparent that a saving in the overall use of all such elements would be made.

It must not be assumed, however, that because a substantial portion of the alloy content of the nickel-chromium-molybdenum NE steels is derived from scrap, any important "dollars-and-cents" economy accrues to the steelmaker. On the contrary, the difficulties and expense involved in testing and segregating scrap more than offset the dollar value of the alloying elements conserved.

Molybdenum and Manganese

The only other alloying elements which appeared to be available to the industry in not too restricted quantities were manganese and molybdenum. The reputation of manganese-molybdenum steels as used in Great Britain for a number of years was carefully considered; English experience was checked and English compositions examined carefully. It was the opinion of our people that a good series of manganese-molybdenum steels could be made, using less manganese and less molybdenum than English practice demands.

With the program set that far, all available hardenability data were collected and studied. It was apparent from the information that certain experimental work would have to be performed. Therefore, a

Fig. 1. Recovery of nickel from scrap.

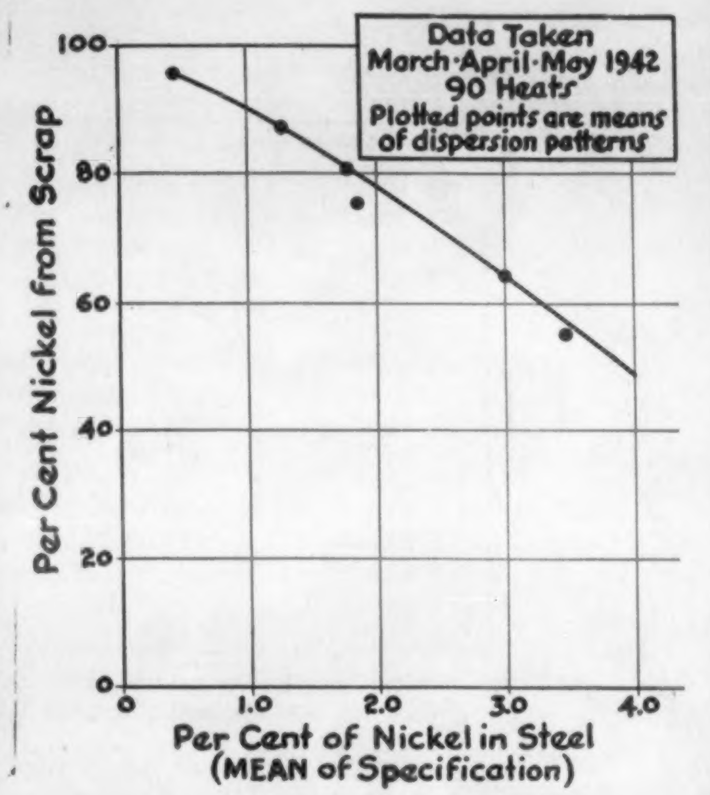
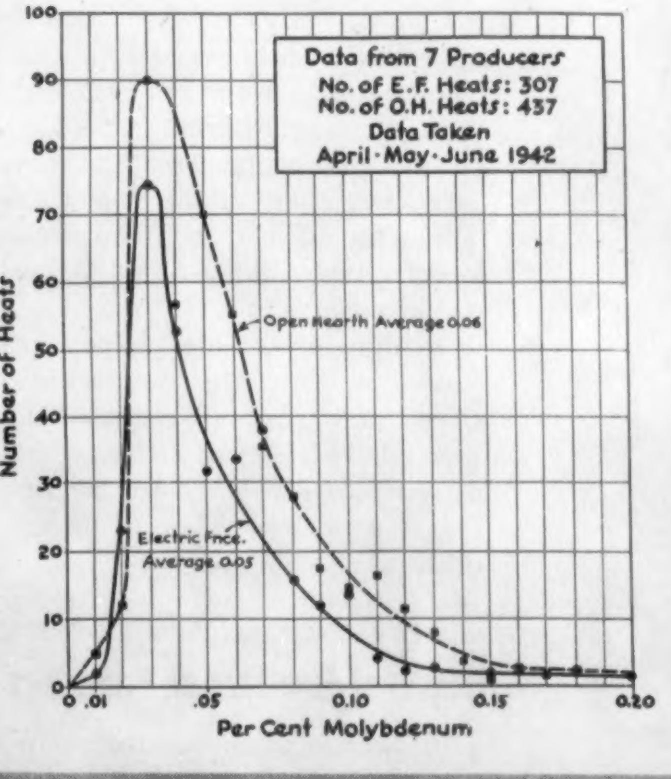


Fig. 2. Residual molybdenum in nickel-chromium steel.



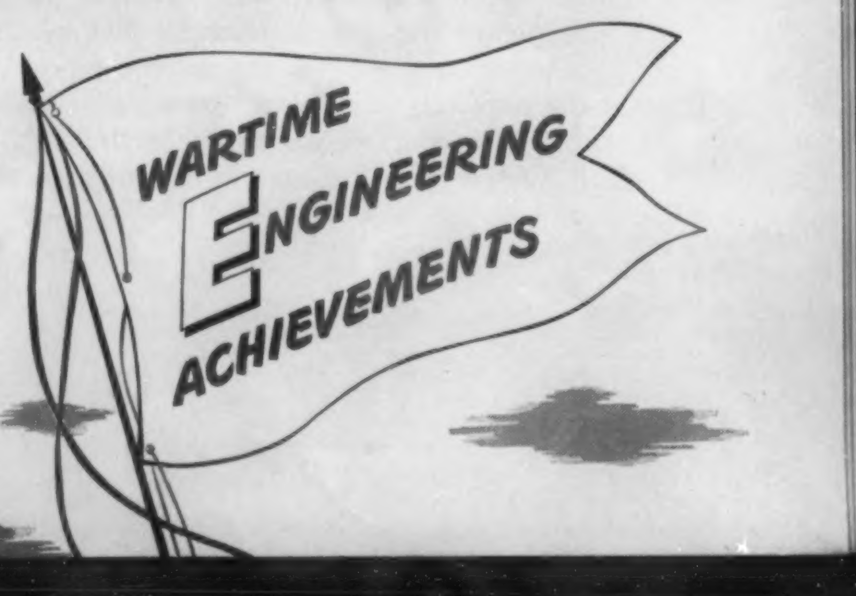


TABLE I

Chemical Composition of the National Emergency Steels

Designation	*Carbon*	*Manganese*	*Molybdenum*	*Nickel*	*Chromium*
NE 8024	0.22/0.28	1.00/1.30	0.10/0.20	—	—
NE 8124	0.22/0.28	1.30/1.60	0.25/0.35	—	—
NE 8233	0.30/0.36	1.30/1.60	0.10/0.20	—	—
NE 8245	0.42/0.49	1.30/1.60	0.10/0.20	—	—
NE 8339	0.35/0.42	1.30/1.60	0.20/0.30	—	—
NE 8442	0.38/0.45	1.30/1.60	0.30/0.40	—	—
NE 8447	0.43/0.50	1.30/1.60	0.30/0.40	—	—
NE 8547	0.43/0.50	1.30/1.60	0.40/0.60	—	—
NE 8620	0.18/0.23	0.70/0.95	0.15/0.25	0.40/0.60	0.40/0.60
NE 8630	0.27/0.33	0.70/0.95	0.15/0.25	0.40/0.60	0.40/0.60
NE 8724	0.22/0.28	0.70/0.95	0.20/0.30	0.40/0.60	0.40/0.60
NE 8739	0.35/0.42	0.75/1.00	0.20/0.30	0.40/0.60	0.40/0.60
NE 8744	0.40/0.47	0.75/1.00	0.20/0.30	0.40/0.60	0.40/0.60
NE 8749	0.45/0.52	0.75/1.00	0.20/0.30	0.40/0.60	0.40/0.60
NE 8817	0.15/0.20	0.70/0.95	0.30/0.40	0.40/0.60	0.40/0.60
NE 8949	0.45/0.52	1.00/1.30	0.30/0.40	0.40/0.60	0.40/0.60

Note: The following additional element specifications apply to all the basic open-hearth steel shown above: Phosphorus 0.040% max.; sulphur 0.040% max.; silicon 0.20 to 0.35%.

program was laid out in which steel producers and producers of ferroalloys melted experimental heats of the new compositions and secured hardenability curves for each steel.

The results of that work were the NE 8000 series steels, the compositions of which are given in Table I.

Those compositions had been in use only five or six months when molybdenum became critical and it became necessary to develop steel compositions containing less molybdenum than had been used heretofore, or no molybdenum at all.

Once again the Technical Committee on Alloy Steel went into action—manufactured experimental heats, forged test bars and secured standard end-quench hardenability data. The results of that work are given in Table II.

In devising all the compositions which are now known as NE steels, consideration was given to the effects of the several elements and the well-known principle that if two elements are equally effective, a greater hardenability will be obtained by using 0.5 per cent of each than by using 1.0 per cent of either of them alone.

Effects of Elements on Properties

In spite of the fact that metallurgy is still an art and not a science, we do know quite a lot about the effects of the several elements on the physical properties of steel. It is true that our quantitative data are not as good as our qualitative data, yet our art is sufficiently well advanced to permit us to predict the general characteristics which will be inherent in a steel of any given composition, using the conventional alloying elements.

Qualitatively we know, for example, that nickel is a ferrite strengthener which contributes to hardenability and toughness; that chromium is a carbide former which increases strength, hardness and toughness and confers stability to heat-treated structures. We know that molybdenum is both a ferrite strengthener and a carbide former, which, in addition to raising tensile strength, hardness and toughness, increases machinability and intensifies the beneficial effects of other alloying elements.

Quantitatively we have records of experience which, when properly compiled and reduced to a least common denominator, can be used to guide us in selecting elements or combinations of elements to do the jobs we want to do.

Hardenability Data As a Guide

After consideration of the alloying elements which could be used in alternate steels and the quantities of each which would be permissible under the provisions of the many limitation orders of the War Production Board, it became necessary to select a means of evaluating the compositions selected in terms of their physical properties. Because an excessive amount of time would have been consumed in making standard tensile and other physical property tests of all the alternate compositions, the Committee was of the opinion that for general applications a comparison of standard end-quench hardenability data would suffice as a guide to the application of the alternate steels.

That decision was based on the well-known fact that hardness is related to tensile strength, yield point and ductility as measured by reduction of area and elongation. Regardless of composition, steels of the same hardness, produced by tempering after hardening, will have the same tensile strength and yield point, provided that the original quenched structure is substantially martensitic.

That reference to the microstructure of steel merits some consideration here because for many years we have discussed chemical composition as the major criterion of performance, and many people are under the impression that because NE steels are lean in alloys they are "different."

The two principal components of the microstructure of steel, whether carbon or alloy, are ferrite and carbide. The physical properties of steel are controlled by the microstructure which portrays the quantity of each component present and its distribution or dispersion.

Microstructure and Heat Treatment

Changing the microstructure of steel is the art of heat treatment. To secure certain desired properties, steel is heated above a certain critical temperature at which its molecular structure changes, carbon and other carbide forming elements such as chromium and molybdenum are dissolved and a solid solution of carbides in ferrite called austenite is formed.

If the hot steel is now suddenly cooled, or quenched as it is called, the austenite is transformed and a new component called martensite is formed. Martensite is a mechanical mixture of carbides and ferrite in a fine state of dispersion—the more rapid the cooling the finer the dispersion, and the harder the product. The cooling rate which just results in complete transformation of austenite to martensite or complete hardening, is known as the critical cooling rate.

Since martensite is brittle a second heating and cooling called tempering is necessary to impart toughness. The tempering operation consists in heating steel to a predetermined temperature lower than the quenching temperature which will adjust the distribution of the carbides in the ferrite to form a coarser microstructure than that exhibited by martensite. This coarser structure is somewhat softer (less strong) and much more ductile than martensite. It is the structure present when the steel is put into service.

The foregoing explanation was based upon treating a piece of steel which was small enough to be cooled all the way through its cross-section at a rate equal to or in excess of the critical cooling rate; that is, the piece was hardened all the way through. If the section was so large that this could not hap-

TABLE II

Type	*Analysis*		
Manganese-Silicon-Nickel-Chromium-Molybdenum steels	Silicon .... 0.40/0.60 Nickel 0.20/0.40	Chromium .... 0.20/0.40 Molybdenum 0.08/0.15	
	Designation	*Carbon*	*Manganese*
	NE 9415	0.13/0.18	0.80/1.10
	NE 9420	0.18/0.23	0.80/1.10
	NE 9422	0.20/0.25	0.80/1.10
	NE 9430	0.28/0.33	0.90/1.20
	NE 9435	0.33/0.38	0.90/1.20
	NE 9437	0.35/0.40	0.90/1.20
	NE 9440	0.38/0.43	0.90/1.20
	NE 9442	0.40/0.45	1.00/1.30
	NE 9445	0.43/0.48	1.00/1.30
	NE 9450	0.48/0.53	1.20/1.50
	Silicon .... 0.40/0.60 Nickel 0.40/0.60	Chromium .... 0.40/0.60 Molybdenum 0.15/0.25	
	Designation	*Carbon*	*Manganese*
	NE 9537	0.35/0.40	1.20/1.50
	NE 9540	0.38/0.43	1.20/1.50
	NE 9542	0.40/0.45	1.20/1.50
	NE 9550	0.48/0.53	1.20/1.50
Manganese-Silicon-Chromium steels	Silicon 0.40/0.60	Chromium 0.40/0.60	
	Designation	*Carbon*	*Manganese*
	NE 9630	0.28/0.33	1.20/1.50
	NE 9635	0.33/0.38	1.20/1.50
	NE 9637	0.35/0.40	1.20/1.50
	NE 9640	0.38/0.43	1.20/1.50
	NE 9642	0.40/0.45	1.30/1.60
	NE 9645	0.43/0.48	1.30/1.60
	NE 9650	0.48/0.53	1.30/1.60

pen, then only that part of the austenite on the periphery of the piece would be transformed to martensite; the balance would be transformed to pearlite, a coarse mixture of carbides and ferrite and would gradually merge into the hardened martensite zone. Obviously then, the steel has not been hardened through and will not exhibit the superior physical properties of a steel which has been hardened through.

Our problem now is to induce the steel to harden throughout its cross-section. This is done by the use of the alloying elements manganese, nickel, chromium, silicon and molybdenum. All those elements lower the critical cooling rate, although not all are effective to the same degree, and permit the steel to harden to greater depths.

The influence of the alloying elements in performing this most useful function is probably threefold: (1) They change the distribution of the carbides in the ferrite matrix by reason of difference in volume; (2) they change the properties of the ferrite by dissolving in it; and (3) they change the quality of type of carbide as compared with iron carbide or cementite.

This elementary explanation is given simply to point out the fact that NE steels follow rigidly the pattern set by nature for all other types of constructional steels and to emphasize the fact that microstructure is of major importance in securing most of the desired mechanical properties.

Factors Affecting Hardness

It is a fundamental fact that the maximum hardness which a given steel can attain by proper heat treatment is dependent almost entirely on its carbon content, while depth of hardness is largely dependent upon its content of alloying elements.

In this respect the NE steels react precisely the same as do the standard steels of the past. Fig. 5 shows the hardness of 45 NE steels at 1/16 in. on the Jominy bar plotted as a function of carbon content. It is significant that the curvilinear relationship of theory and research is maintained even though the data were taken from commercial tests which were run on commercial heats, and that all types of NE steels are represented.

The standard end-quench hardenability tests given in Fig. 6 illustrate clearly the principles (1) that maximum hardness is a function of carbon, (2) that depth of hardness is a function of alloying elements, and (3) that small quantities of several properly selected elements are more effective in influencing hardenability than a large quantity of a single element.

The curve for A 1035 is typical of a carbon steel; it identifies a shallow-hardening steel by reason of the low Rockwell values at ¼ in. and beyond. The curve for A 1330 illustrates first, the maximum hardening power of carbon uninfluenced by alloying elements and, second, the influence of an alloying element, in this case manganese, in increasing depth of hardness. The manganese content of the A 1035 was 0.78 per cent while that of the A 1330 was 1.82 per cent; the carbon contents of the two steels were practically identical.

The curve for A 2335 illustrates the increased maximum hardness due to increased carbon and the increased depth of hardness due to 3.5 per cent Ni. The curve for NE 8744 further illustrates maximum hardness due to carbon and also shows the hardening power of small quantities of several properly selected alloying elements. The alloy content of the NE 8744 was manganese 0.85 per cent, nickel 0.50 per

Fig. 3. Residual nickel in chromium-molybdenum steel.

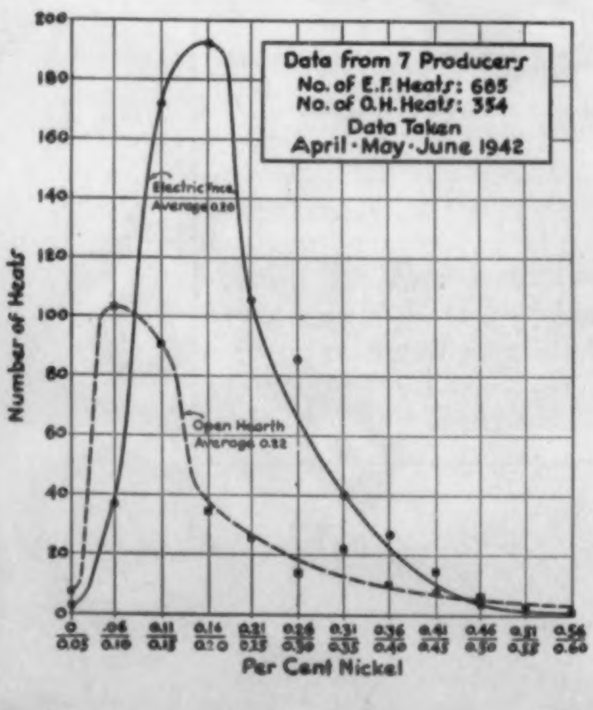


Fig. 4. Residual chromium in nickel-molybdenum steel.

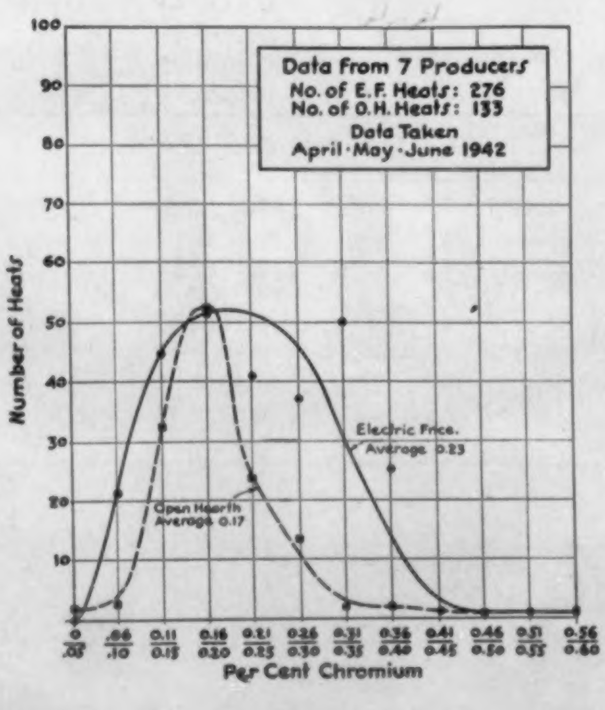
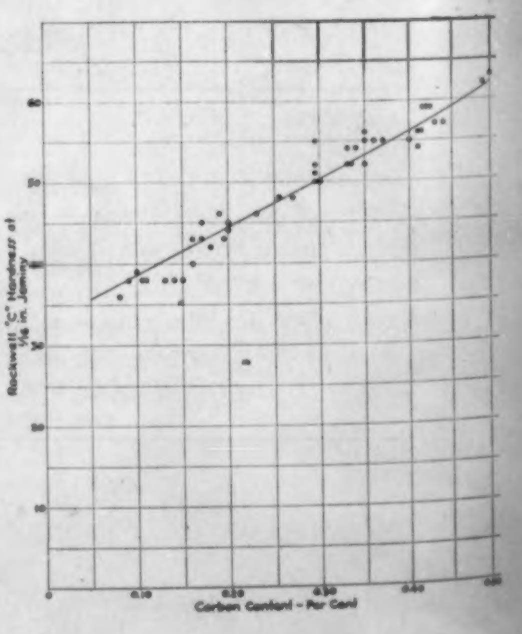


Fig. 5. Relationship between sub-surface hardness and carbon content of NE steels.



cent, chromium 0.51 per cent and molybdenum 0.23 per cent.

Fig. 7 shows graphically the hardenability relationships among certain of the alloying elements and Fig. 8 gives the approximate hardenability levels of standard and NE 8000 series steels. The normal expectancy for the ordinary mechanical properties of the NE 8000 series steels: Tensile strength, yield point, elongation and reduction of area are given in Figs. 9 to 12, inclusive.

Manganese-Molybdenum Steels

The introduction of manganese-molybdenum compositions as National Emergency steels did not bring anything new to metallurgy, although the balance of elements used in NE steels was new. Steels of that type have had a long record of worthwhile service, both in England and the United States. During 1941 an average of 10,000 tons per month was produced for domestic consumption in such applications as: Automotive crankshafts, dredge buckets, rock crusher parts, locomotive tires and train couplings.

Manganese-molybdenum steels are characterized by their high impact values and their resistance to fatigue. In addition, it is reported that they are:

(1) Easy to forge.
(2) Easy to machine.
(3) Have good weldability.
(4) Have stable physical properties at high temperatures.
(5) Have practically no temper brittleness.
(6) Respond well to heat treatment.
(7) Develop good depth of hardness.
(8) Exhibit minimum mass effect in heat treatment.
(9) Have good ductility.

Fig. 6. Standard end-quench hardenability tests—effects of carbon and alloying elements.

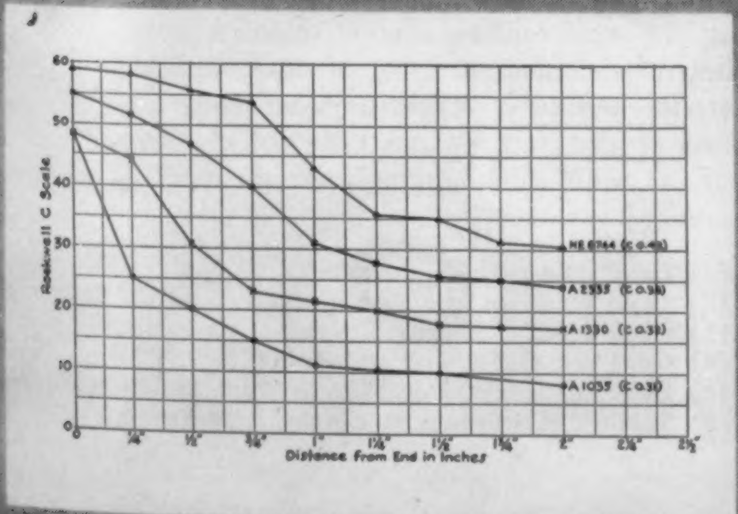
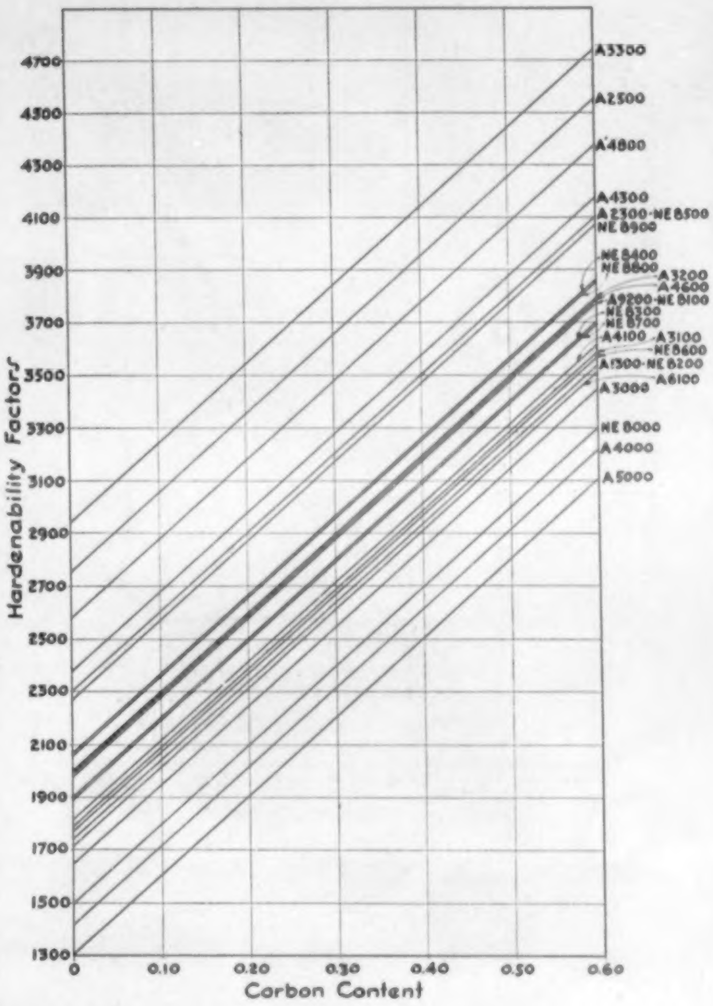


Fig. 7. Hardenability factors.



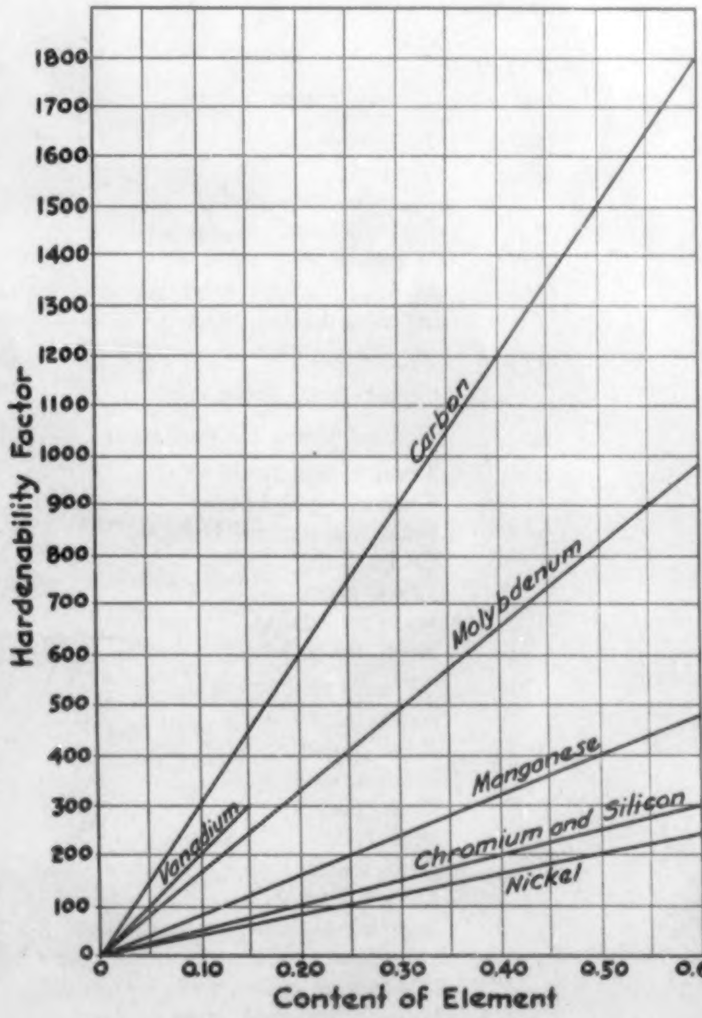


Fig. 8. Approximate hardenability levels.

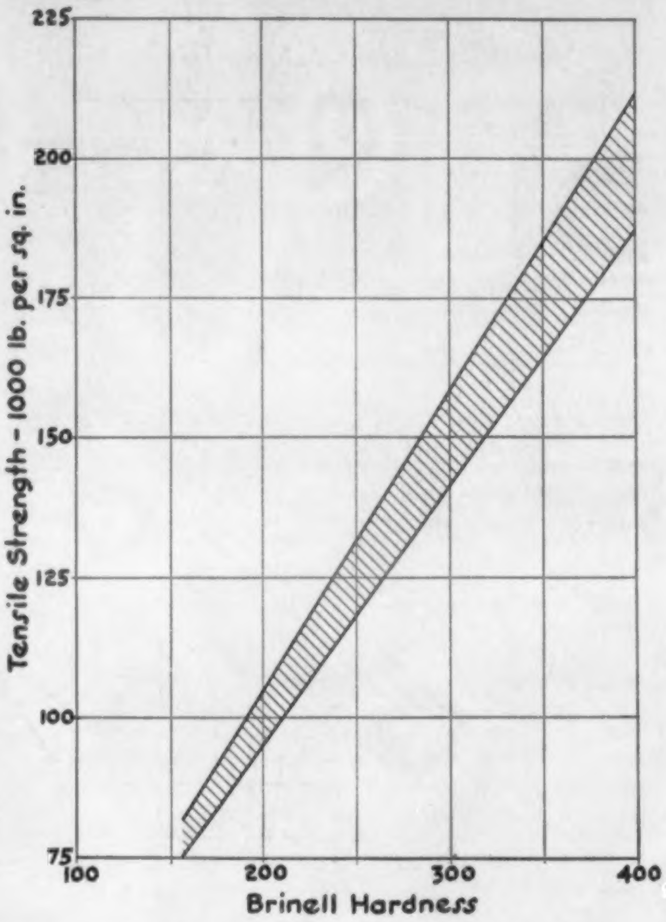
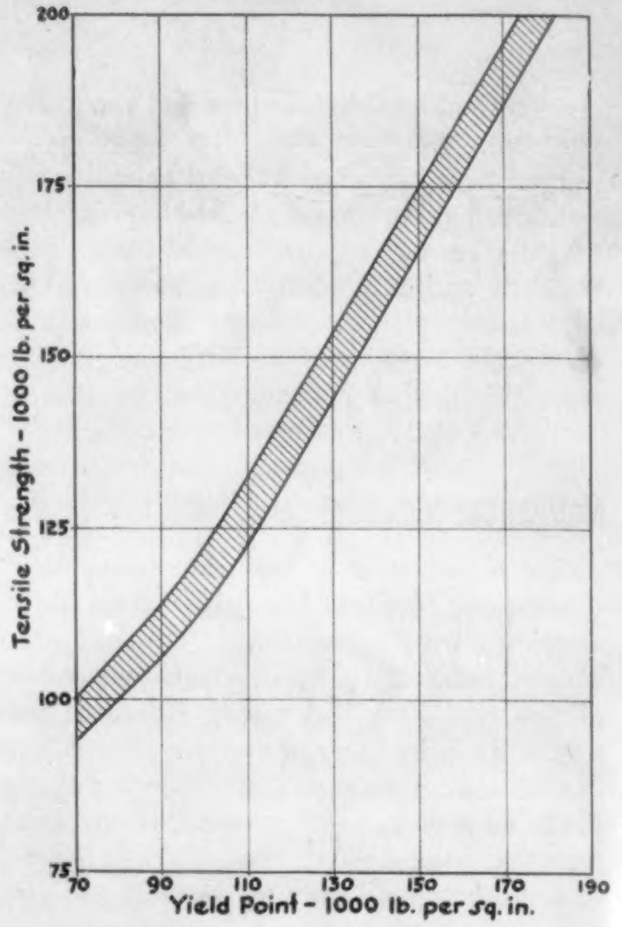


Fig. 9. Relationship between Brinell hardness and tensile strength. NE 8000 Series steels, normal expectancy.

Fig. 10. Relationship between tensile strength and yield point. NE 8000 Series steels, normal expectancy.



Among the specific jobs which manganese-molybdenum NE steels are now doing are the following:

NE Steel in Use	*Application*	*Standard Steel Replaced*
8024	Ball studs	3115
	Tools	4615
	Machine tool shafts	4620
	Steering gear worms	4120
	Worm gears	4615
	Milling machine drive gear and spindle	4615
	Steering cams	4120
8124	Tractor pinions, drive gear, differential ring gear, brake shaft	4120
8245	Tractor power take-off shaft	4142
8339	Steering arm studs	3045
	Connecting rod bolts	2340
	Brake adjustment bolts	3140
	Chain links	3140
	Truck gears	4140
	Seamless tubing	Special
	High stress bolts	3135
8442	Oil well tool joints	3140
	Socket wrenches	4140
	Aero propeller wrenches	4640
	Stillson wrenches	6140
	Chain pins	5150
	Die inserts	4140
	Drill shanks	4140
	Tractor rear axles	4142
	Low temperature studs	4142
	Locomotive side rods	Special
	Locomotive piston rods	Special
	Locomotive crank pins	Special
	Propeller stud shafts	3135
	Bull gears (tractor)	4145
8447	Steering knuckles	3140
	Lever holders	4140
	Tractor shafts and gears	4145
	Truck axles	4150
8547	Gears	4150
	Truck axle shafts	4145
	Truck axle shafts	4340

Nickel-Chromium-Molybdenum Steels

It has been shown that industry-wide it has been almost impossible to produce a nickel-chromium steel without some molybdenum, a nickel-molybdenum steel without some chromium, or a chromium-nickel steel without some molybdenum. The quantities of residual alloys contained have for the most part been present in sufficient quantity to alter the characteristics of the specified steel to such an extent that it can fairly be said that, with few exceptions, the steel industry has produced a nickel-chromium-molybdenum steel rather than a nickel-molybdenum steel or a nickel-chromium steel.

Because of that fact we can state the characteristics of a nickel-chromium-molybdenum steel as follows:

(1) Good fatigue-tensile properties.
(2) Good toughness at high hardness.
(3) Good depth hardness.
(4) Good response to heat treatment.
(5) Good strength and ductility in heavy sections.
(6) Stability of structure at elevated temperatures.

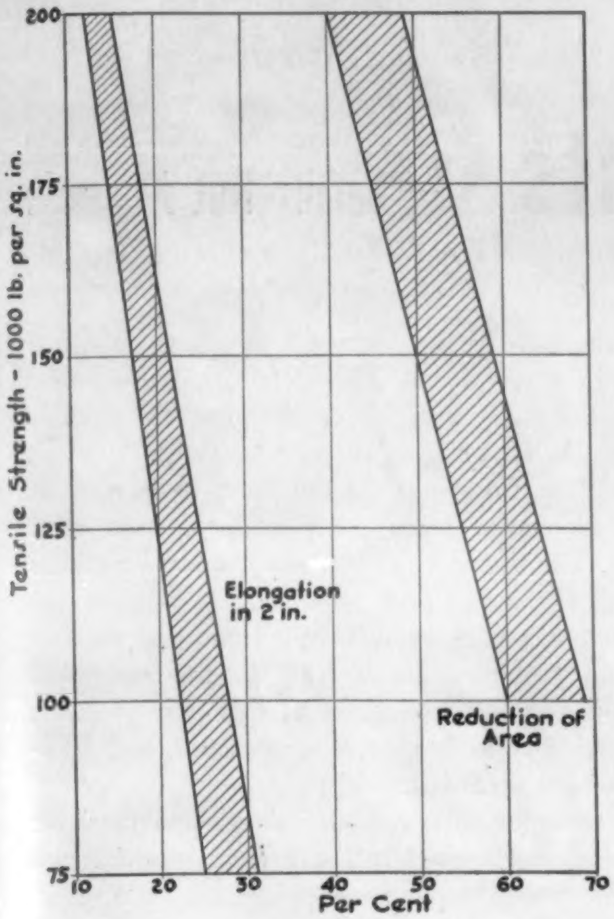
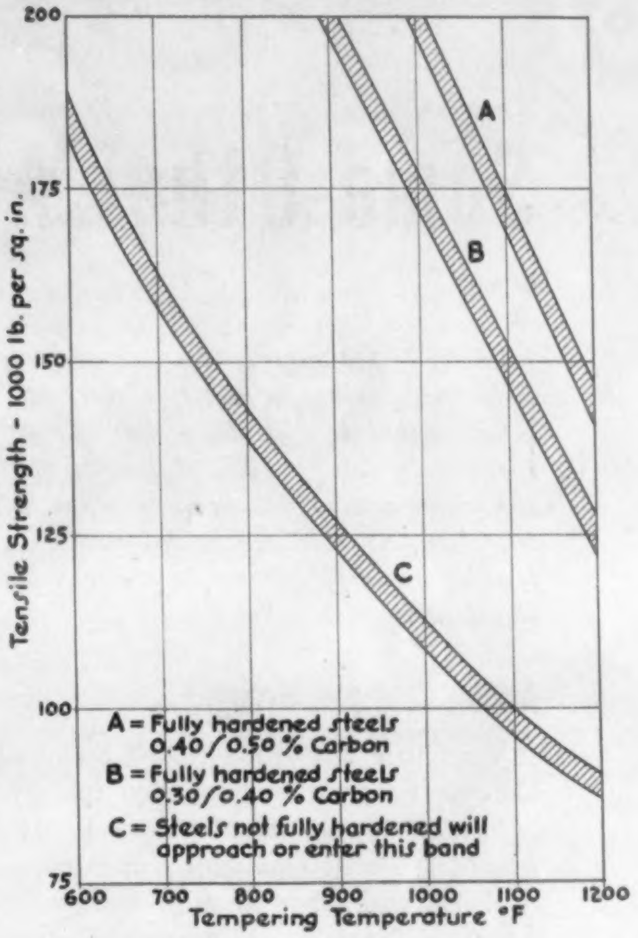


Fig. 11. Left: Relationship between tensile strength, reduction of area and elongation. NE 8000 Series steels, normal expectancy.

Fig. 12. Right: Relationship between tensile strength and tempering temperature. NE 8000 Series steels, normal expectancy.



(7) Good machinability.
(8) Good uniformity of case.
(9) Relative freedom from distortion.
(10) Resistance to abnormal grain growth.

Among the specific jobs which the NE nickel-chromium-molybdenum steels are doing are the following:

NE Steel in Use	*Application*	*Standard Steel Replaced*
8620	Transmission gears	4120
	Clutch gears	4815
	Air drill parts	2315
	Ring and pinion gears	4620
	Chuck jaws	4615
	Flywheel starter gears	4820
	Coal cutting chain bushings	4615
	Machine tool gears	2315
	Roller bearing cups and cones	3120
	Transmission spline shafts	3120
	Rear axle drive pinions	4320
	Differential spiders	6120
	Diesel engine bolts	4615
	Constant-mesh gears	4120
	Rear axle ring gears	4620
8630	Steering arms	4130
	Cutter bitt holders and wedges	6135
	Hand tools	4130
	Aircraft engine bolts	2330
	Front axle centers	3130
8724	Bearing cones	4620
	Differential pinions	6130
	Tractor gears	4820
	Tank sprockets	6130
	Transmission gears	6120
	Ring gears	4120
	Pinions	4820
8739	Bolts	3130
	Mining machinery parts	4137
	Transmission gears	5140
	Aircraft engine bolts	4140
	Truck transmission gears	4640
	Tank sprockets	4640
8744	Machine tool parts	3140
	U-bolts	4142
	Spring clips	4142
	Tractor gears and shafts	2345
	Set screws (heavy duty)	3145
	Engine bolts and studs	4140
	Seamless tubing	Special
	Digging teeth	6145
8749	Pins	3250
	Machine tool parts	2350
	Pneumatic tool parts	4640
	Machine tool gears	4150
	Transmission gears	5150
	Antifriction roller bearings	5152
8817	Coal cutting chain straps	4320
	Carburized transmission gears	3115
	Machine tool parts	3115
8949	Axle shafts	3240
	Truck clutch parts	3240
	Gas engine connecting rods	4340
	Milling machine transmission gears	2345
	Oil well machinery parts	3145
	Lathe parts	3250
	Lifting jacks	4640
	Track pins	3250

Some Other Achievements —Details Not Available

Many of the engineering achievements in the metal industries during the last two years or so are of such a nature that detailed discussion of them, for obvious reasons, is not possible. A brief listing of some of the major ones is, however, in order. It is the object, therefore, of this article to present several of the leading accomplishments, not elsewhere discussed in this issue.

Armor, Cast and Wrought

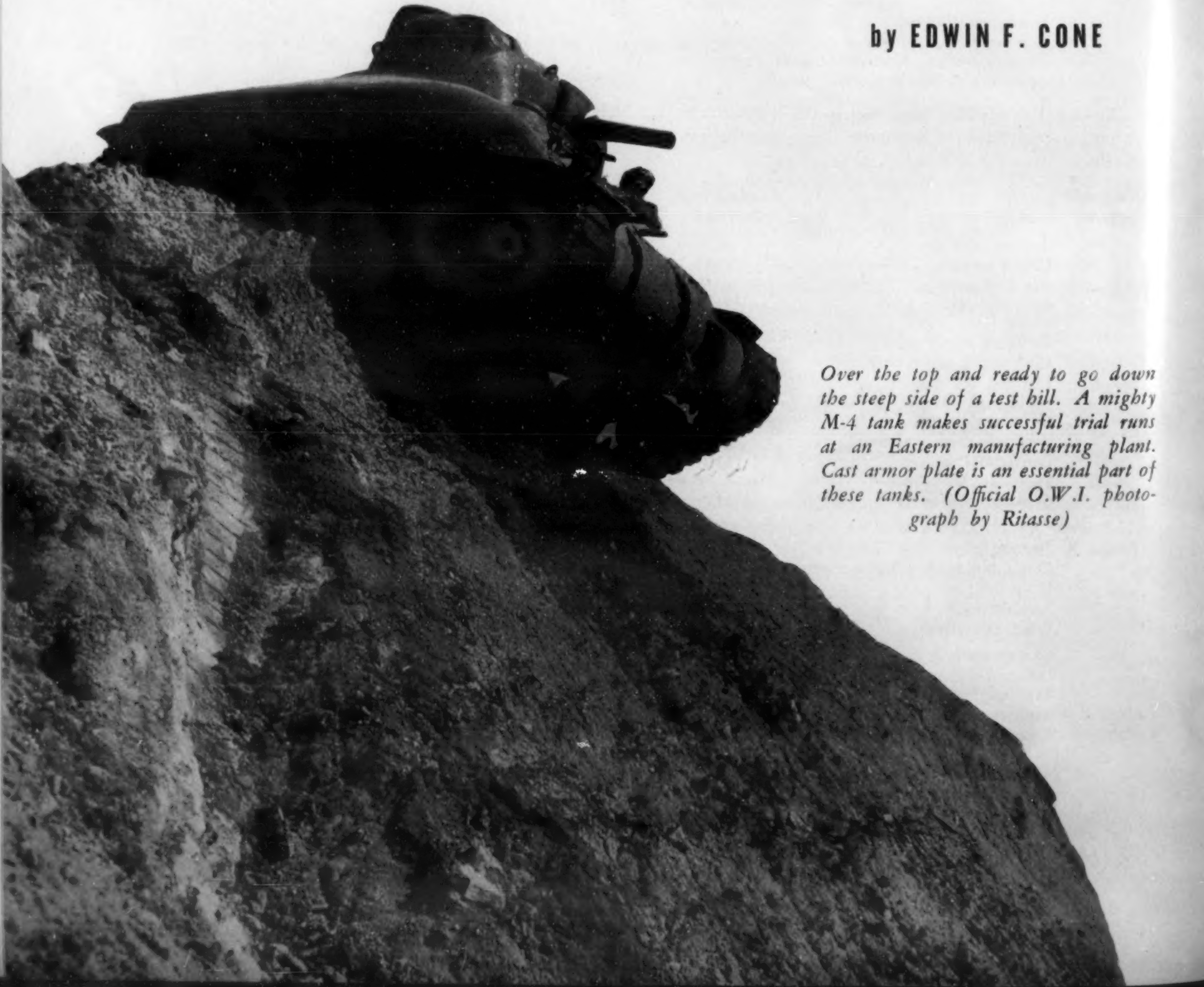
Very little was heard of cast armor plate until the Defense Program was initiated in 1940. It consists of certain forms, large and small, made by a few American steel foundries for incorporation in tanks, airplanes and other mobile military equipment. As the War Program has developed, demand for cast armor plate has greatly expanded.

Its production may be classed as a metallurgical engineering achievement. The metallurgical, foundry and heat treatment practice cannot now be told. It will some day be a highly interesting story.

Chemical specifications do not have to be met in making cast armor plate—only ballistic tests must be passed. The foundry can use any chemical analyses which, after suitable heat treatment, will pass the ballistic requirements. In this, heat treatment practice plays an important role. In fact in the successful prosecution of the manufacture of this type of plate, definite progress in heat-treating practice and technique has been recorded.

As to wrought armor plate, developments have been expansive. Previous to the present world crisis, most of the wrought plate was made for battleships, cruisers, etc.; it was mostly heavy plate, over 3-in. thick.

by EDWIN F. CONE



Over the top and ready to go down the steep side of a test hill. A mighty M-4 tank makes successful trial runs at an Eastern manufacturing plant. Cast armor plate is an essential part of these tanks. (Official O.W.I. photograph by Ritasse)

As our present Defense and War Program developed, demand for light plate, from about 1/8 to 3 in. thick, increased. It has now reached very large proportions. This type of wrought plate is used in varying thicknesses in the construction of airplanes, bombers, tanks and so on.

In this case also, as in the production of cast armor plate, chemical compositions are not specified, only ballistic requirements must be met. And in this, heat treatment has been and is a major factor. Not only have the engineering problems involved been difficult to solve but the alterations and improvements in heat-treating technique have been striking. One important development has been the perfection of a method and equipment for the continuous heat treatment of this material, resulting in a decided saving in labor and time as contrasted with the batch method.

Steel Cartridge Cases

One of the most important recent engineering achievements in the metal industries is the production on a large scale of cartridge cases of steel to supplant those made of brass. Reliable information is to the effect that this very difficult problem of substitution has been solved. It means the release of an estimated quantity of 900,000 tons of copper a year, as well as a substantial tonnage of zinc, for other essential purposes.

In the July issue of METALS AND ALLOYS, page 43, an editorial—"Steel Cartridge Cases"—was published, which was based on an interview with the Ordnance Department at Washington and which was passed for publication. From this we quote:

> "****The problem of the free substitution of steel cases for brass has never been licked by any nation thus far.
>
> "It can now be stated that Army Ordnance and American metallurgical engineers have practically solved this exceedingly difficult problem. And that in a few months steel cases will be substituted to a very large extent, if not wholly, for the familiar brass product.
>
> "Unfortunately for the metallurgical world, the details of this story cannot now be told—it would divulge information to the enemy. But when the information on how the many intricate problems that have arisen have been solved is released, there will result a story that will not only be intensely interesting but one that will reveal new knowledge regarding some metallurgical problems and perhaps revolutionize our fundamental conception of certain phases of the drawing of steel."

The metallurgical engineering world is eagerly waiting for an opportunity to study the details of this achievement.

Centrifugal Casting

Several outstanding products, made by the centrifugal casting process, have been one of the results of the war effort.

The most prominent among these has been the centrifugal casting of steel aircraft engine cylinder barrels by the Ford Motor Co. This metallurgical engineering achievement has reached mass production proportions.

Savings in time, in steel, in machining and in cost of equipment are important features of this new development which supplants the forging method. There is an initial saving of 35 lbs. or 48 per cent in the steel used—the steel block for the forged cylinder barrel weighs 72 lbs. while the centrifugally cast cylinder barrel weighs only 37 lbs. The bursting strength of the centrifugally cast product is 9,200 lbs. while that of the forged cylinder is only 6,000 lbs. The steel used is S.A.E. 4140, a chromium-molybdenum analysis.

The savings resulting from the use of this centrifugal method are highly important under present conditions where maximum output at lower cost is so essential.

Ford has pioneered in recent developments in centrifugal casting. Some 4 yrs. ago his engineers developed a process for centrifugally casting steel gear blanks, now on a mass production basis. Coincidentally with the perfection of the casting of the steel cylinder barrels, Ford engineers have also developed centrifugal casting methods for the production of landing gear axles, solid projectiles, etc.

Pipe foundries have long used centrifugal casting methods, and centrifugal casting of guns instead of forging them has likewise been long established. The dentist has used centrifugal casting for non-symmetrical objects in gold alloys, using centrifugal force to fill the mold instead of big heads and risers. Large scale application of dental casting technique is here for a few applications in other metals and a considerable extension is coming fast.

Magnesium and Aluminum

In our extensively expanded aircraft program, aluminum and magnesium are essential metals. The increased demand for them has caused the installation of new plants and processes for their production — metal-industries engineering achievements of a high order.

Magnesium, until the new demand arose, was made on a relatively small scale by the electrolysis of magnesium chloride—the standard method of the

Dow Chemical Co. In the early stages of the expansion this company established a plant in Texas for the recovery of the metal from seawater. This is now in production but engineering details of the plant and the process are not available.

Supplementing the familiar Dow and other processes for producing magnesium, the ferrosilicon reduction method has come into the picture. Several plants are being built in Canada and this country which will soon go into production, using this method in some form. Only general facts are available—high grade ferrosilicon is mixed with dolomite, heated in a vacuum whereby magnesium is distilled and sublimed. The practically pure metal can be removed from the retorts in solid form. About one-fifth of the total magnesium output, it is estimated, will be made by this process.

The magnitude of this expansion program may be appreciated from the following data—in 1940 the output of magnesium was only a little over 6,250 net tons. This had increased in 1941 to about 16,500 tons. According to reliable estimates the 1942 total will approximate 362,500—an expansion over 1940 of nearly sixtyfold.

In aluminum the tremendous expansion in output has not involved new processes of production—the reduction from bauxite still is standard. The output for 1943 should reach, according to reliable estimates, about 1,250,000 net tons. This contrasts with 541,500 tons in 1942 and only 166,500 tons in 1939.

Aluminum and magnesium constitute the backbone of our airplane and airplane engine production. It is not impossible that investigations now under way looking to the use of some special type of steel in place of aluminum may be fruitful. Certainly such success would be classed as an engineering achievement in the metal industries.

Other Non-Ferrous Metals

The achievements in meeting the tremendous war demand for copper, zinc, lead and nickel are not only striking in their results but are quite familiar to the average metal man.

Lead is in a fairly comfortable position as to supply. Zinc resources are better than they were earlier in the emergency. The allied nations virtually control the world supply of nickel. Domestic production and imports of copper are estimated to total 1,800,000 tons this year which, with scrap added, will make over 2,000,000 tons available. In 1939 about 800,000 tons were used.

These expansions in production to such record figures are a credit not only to the managements of the respective industries but are also evidence of what can be done by concerted and cooperative metallurgical engineering. These statements apply

Wrought and cast armor plate is used in the construction of these large American airplanes and bombers. Centrifugally cast engine cylinder barrels are employed in some of the Pratt & Whitney engines.

also to the tin and tungsten situations—both alleviated by the new tin smelter in Texas and the newly developed tungsten deposits in the West.

The Steel Industry

The achievements of the Americal steel industry deserve some brief comment in this general picture or review.

This global war is a war of metals and of these steel is the backbone. It is generally conceded that, in the long run, the nation or group of allied nations that has the most available steel will win a war. The Allied Nations certainly are superior to the combined enemy in pig iron and steel capacity.

The American iron and steel industry, throughout the Defense Program and later since Dec. 7, 1941, has performed a signal engineering achievement. Because its equipment, during the very lean years of the '30's, had been kept in first-class condition and ready for any demand, the industry was able to gear its production of both pig iron and steel to meet the demands of the '40's. Today the industry is making more pig iron and steel than at any time in its history. Each month the average steel ingot production of about 7,000,000 net tons is more than Japan can make in a year. Present operating rate points to a total of about 86,500,000 tons for 1942, a new record.

As this large output of steel and pig iron has expanded, capacity has also been enlarged. During the first half of this year 628,350 net tons has been added, mostly electric, bringing the steel capacity to 89,198,-320 tons. Pig iron capacity has also been enlarged by 442,500 tons to July 1, this year.

Both of these reflect credit on the industry—it is no small accomplishment with the equipment pushed almost to its capacity.

Miscellaneous Achievements

The list of metal-industries engineering achievements could be considerably expanded but it will suffice to mention a few others very briefly.

Research work that has been done on substitutes for tin, particularly in solders, is outstanding in its fruitful results. Several articles and papers have been published in this and other magazines.

Considerable work has been done on the use of our large supply of silver in the production of new alloys and especially on its substitution for tin and other metals.

There are two important war products the complete story of which when told will be of prime interest and importance as metallurgical engineering achievements—the supercharger and gas turbine, and the forged aluminum cylinder head for airplane engines.

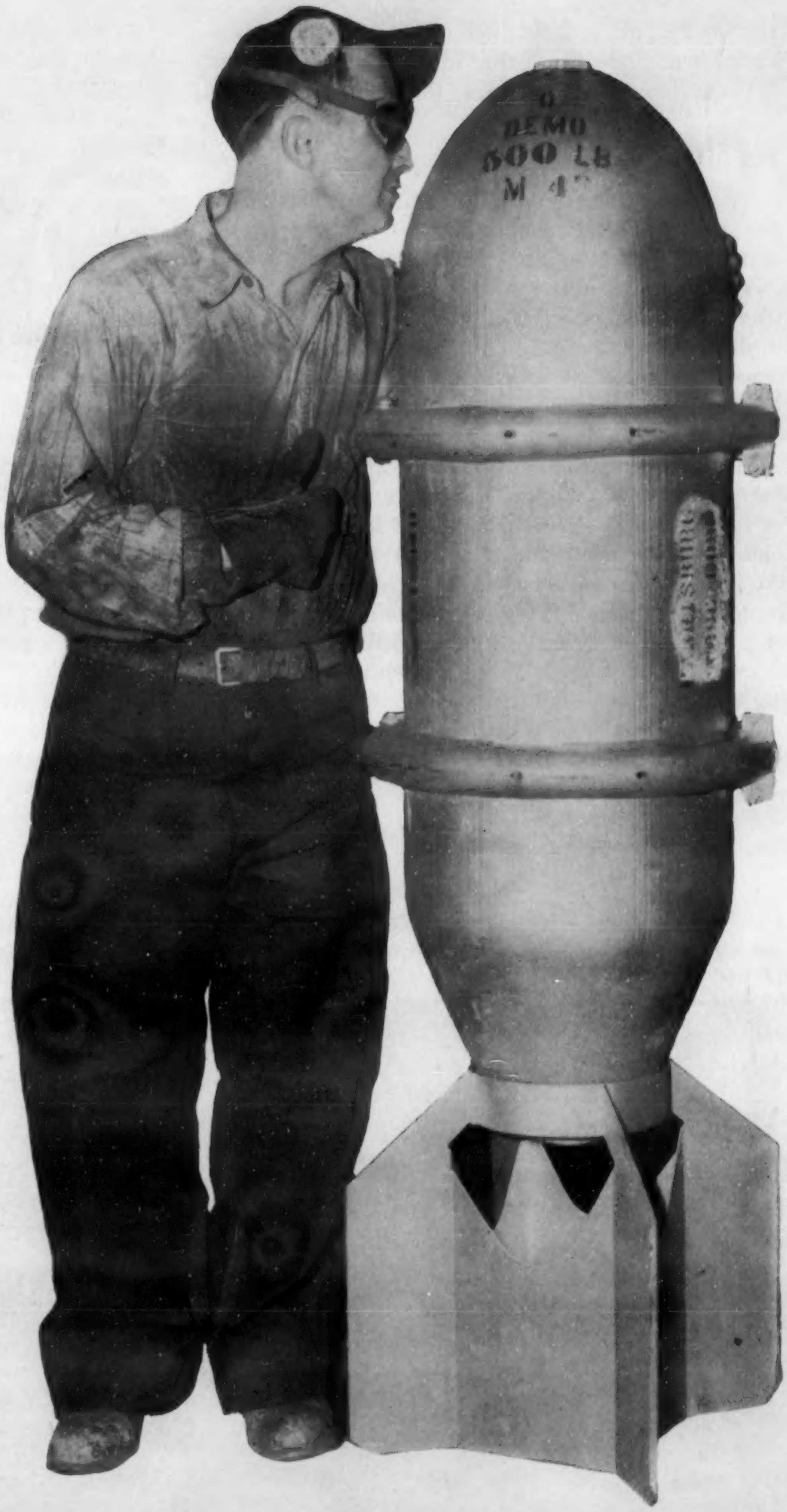
In the massive cast-steel hull of this M-4 tank, a crew of hardbitten "tankers" is rehearsing a few fighting tricks at a training school of the armored forces at Fort Knox, Ky. (Official O.W.I. photograph by Palmer)

Welded Demolition Bombs

Methods of expanding or improving the production of demolition bombs are of obvious military value, since this war is plainly going to be won in the air and with the use of bombs. A notable engineering achievement of the last few years has been the development and use of a process for making demolition bombs by welding. This article gives many of the processing details and some incidentally interesting sidelights on the relative advantages of cast, forged and welded demolition bombs.
—The Editors.

by JOHN J. TARGET

Chief Inspection Section, Ammunition Div., Philadelphia Ordnance Dist., War Dept.



Ready for shipment to an Ordnance Dept. loading plant to be filled with high explosives, this 500-lb. demolition bomb is getting a final examination. Fins, attached here for photographic purposes, are put on at air fields. Bands around the bomb are to facilitate handling. (Courtesy: U. S. Army Signal Corps.)

THE SUBJECT OF DEMOLITION BOMBS is an important and timely one since the outcome of the present conflict depends to a great degree on our effectiveness in the air—not only on the superiority of our planes, but also on the quantity and quality of the bombs which those planes can drop on vital enemy positions. An integral part in the manufacture of demolition bombs is the fabrication of the bomb casing.

There are three methods generally employed: Casting, forging and welded construction. This article will deal with the metallurgical engineering aspects of one type of welded demolition bombs which has recently been developed. It will include the design considerations and materials involved, a description of the fabricating, heat-treating and finishing procesesses, the testing, and a comparison between the welded bomb and other types of construction.

Design Considerations

A demolition bomb is defined by the United States Ordnance Department as an explosive projectile that is made to be dropped from aircraft and is used for destroying structures and material where the resultant damage is affected by explosion or blast. The bombs range in size from 100 to 2,000 lbs. loaded. They are generally cylindrically shaped in the center, with a blunt ogival, or elliptically shaped nose, and a truncated conical tail to which fins are attached. Two lugs for suspending the bomb from the airplane are fastened to the body, one about a third of the length of the bomb back from the nose; the other the same distance from the tail.

The primary purpose of the demolition bomb is to cause destruction of industrial plants, arsenals and munition dumps, fortifications, docks, buildings, etc. To do this effectively the bomb must be designed so that it will not rupture or explode until it has penetrated its objective to the maximum depth. The optimum performance of a bomb is the complete penetration of the object to the section below the street level before demolition occurs. Demolition bombs are designed toward that end.

Since the properly designed bomb requires that it remain intact until the objective has been fully penetrated, the ogival nose, side wall, and tail section must be sufficiently strong to withstand the various impacts of penetration. The critical section is the nose extending back about one-third the length of the bomb to the first suspension lug. This portion is subjected to the severest stresses and, therefore, has the thickest section and is the heaviest part of the bomb.

During the first World War, experience lacking, it was believed that the bomb would be sufficiently effective if the nose alone was of a heavy construction and the side walls designed merely strong enough to contain the explosive charge. Numerous tests, and experience within the last few years, proved this conception to be wrong. It has now been definitely proven that the ability of the side walls to withstand the impacts during penetration is of equal importance. Likewise in the welded design the longitudinal weld must have a strength equal to that of the base metal of the bomb to avoid rupture during penetration preliminary to the explosion.

As another precaution against premature explosion, it is necessary to obtain a bomb cavity (inside of bomb) surface completely free of defects such as pits, seams, laps, etc. Such irregularities might possibly cause ignition of the charge either while in storage or while the bomb is being used.

The Process, Material, and Properties

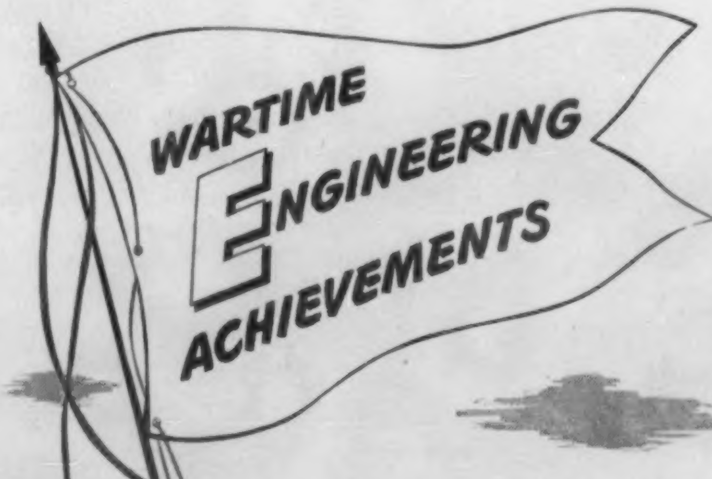
Up until relatively recent years almost all heavier class demolition bombs were made by forging processes. However, with the improvement in welding, welding design, and the introduction of rapid automatic welding methods, an increasing number of bombs are being made of welded construction. During the World War I some 100-lb. aerial bombs were hand-welded. The pioneering manufacturer who accomplished this is now on the mass production of demolition bombs made of a single length of flash-welded tubing, the nose and tail being formed under a heavy, automatic die-forging hammer. It is said that this method cuts costs around 25 per cent on this particular size bomb.

The Ordnance Department has experimented for some time to develop welding procedures for demolition bombs. A method was devised—described in this article—whereby the bomb casing is rolled from sheet steel into a cylindrical shape; the resulting longitudinal seam is then joined by an automatic welding process after which the casing is shaped to its final form by forging the nose and tail.

The material used for welded demolition bombs is a low carbon alloy steel, 0.15 to 0.20 per cent C with sufficient alloys to bring the steel up to the required physical properties after heat treatment. Government specifications require rigid adherence to required physical properties.

Rolling and Preparation for Welding

The first step in the manufacture of welded bombs is to prepare the longitudinal edges of the steel plate



cut to size, for welding by planing the edges. The edges are so planed that when they meet they will form a vee type joint with an included angle of about 30 deg. After the planing operation the plates are crimped in a small crimping press just enough to prepare their edges for rolling. The plates are then cold rolled into cylinders.

When the bomb cylinders come off the rolls they are clamped rigidly into a jig which consists of a number of wire cables slung around the cylinder and tightened by a compressed-air apparatus. In this position the edges of the bomb cylinder are brought tightly together so that they can be tack-welded in place. The tack welds, from 1/2 to 1 in. long, are placed about every 6 in. along the longitudinal seam. Two small steel tabs about 4 in. square are also welded on each end of the cylinder at the longitudinal seam. These tabs serve as a starting or stopping point when the seam is being welded with the automatic machine.

As a final preparation for welding, the longitudinal seam is thoroughly cleaned by a rotating wire brush. Cleanliness and freedom from moisture are absolutely essential in order to obtain a clean, sound weld. The bomb cylinder is then ready for welding.

The Welding Process

The welding is done by the "Unionmelt" process. An automatic welding head is employed through which steel welding rod can be fed at rates of from about 1/3 lb. to about 1 lb. per min., depending upon the thickness of steel being welded. With this process no flashing arc is seen. A granulated material of special properties, known as Unionmelt, is fed by gravity through the welding head and laid along the seam to sufficient depth to cover completely the welding zone and the end of the bare steel welding rod. As the welding progresses the arc causing the melting of the rod and fusion is hidden beneath the melt; part of it next to the weld is fused and adheres lightly to the weld. Upon cooling, it is easily removed. The unfused portion of the Unionmelt is retrieved for re-use.

In the application of this automatic welding process to bomb construction, the cylinder is placed on a welding jig which essentially consists of a holding fixture, a trough filled with granulated "Unionmelt" under air pressure for backing-up the first pass, and a track upon which the welding head runs.

The welding is finished in two passes. The first weld pass is laid along the seam from the inside of the cylinder and completely penetrates the plate thickness. The weld is backed-up, as mentioned above, by granulated melt under pressure in a trough upon which the longitudinal seam rests.

After completing the inside pass the outside seam is grooved with a chipping hammer to remove any slag or minor gas holes, in preparation for the final pass. This final weld is made in much the same manner as the first, except that no backing-up material is needed, since in this case the inside weld serves that purpose. The welding is done at the rate of about 14 ft. per min.

Welds Radiographically Inspected

When the welding operation is completed, the bomb is removed from the welding position, the two tabs at the ends of the bomb cylinder are removed and the edges smoothed by chipping and grinding. The reinforcement on the outside weld is then removed flush to the surface of the cylinder; the weld is gound smooth so that the outside surface of the bomb cylinder has the appearance of seamless tubing. Four to six inches of the weld reinforcement at each end of the inside pass is also ground off flush with the body of the cylinder. This is done in preparation for the forming of the nose and tail.

The welded seam on one out of every 10 bomb cylinders manufactured must undergo a rigid radiographic examination. The purpose of this test is to have a close check on the quality of the welding procedure and to insure a good, sound weld before the nose and tail are formed. If the one bomb cylinder, picked at random from every lot of 10, fails to pass the X-ray test, all 10 in that particular lot must be X-rayed. If any defects, such as undercuts, slag inclusions, porosity, lack of fusion, or cracks which surpass the limits allowed are found, they must be repaired and a passable radiograph secured before the cylinder is acceptable for the forming operations.

The standards of acceptance for the radiographs are based on an official set of radiographs from the Watertown Arsenal. The standards require a very nearly perfect weld, but under proper welding conditions no difficulty is experienced in obtaining an acceptable weld.

When weld repairs are necessary, the defect as shown on the radiograph, is removed by chipping and the repair is made either by electric-arc, or by a small hand operated "Unionmelt" machine.

Forming the Nose and Tail

The forming of the nose and tail of the bomb is performed by a series of forging operations in which about a third of the cylinder at each end is swedged down to the finished contour by a 2,000-lb. forging hammer. During the forging operation the metal at the ends of the bomb cylinder is partially upset so that the thickness through the nose and tail section of the finished bomb is considerably greater than at the center of the bomb body.

The bomb cylinder is heated for forging by sticking about one-third the length of the cylinder into

a furnace and heating it up to 2,100 to 2,200 deg. F. When the heat is reached, the cylinder is removed from the furnace and placed on the stationary die of the forge and revolved rapidly at about 60 r.p.m. while the moving die of the forging hammer shapes it to the finished nose contour. Three heats are ordinarily required to swedge the nose to the finished dimensions. A round metal plug is inserted at the extreme end of the nose before the final forging so that an opening can be maintained at this point.

The tail is formed in a similar manner, except that only one heat is required for this operation. Either the nose or tail may be forged first depending upon the particular production set-up used.

In a section of a U. S. Steel Corp. bomb factory, the National Tube Co. "spins" out "eggs" by revolutionary process approved by the U. S. Army. (Courtesy: U. S. Steel Corp.)

"Nosed in" by a 1700-lb. steam hammer, a 1500-lb. demolition bomb forging is being removed preparatory to hammering in the bomb "neck" through which it will be loaded with high explosives to which bomb fins will be attached. (Courtesy: U. S. Army Signal Corps.)

Heat Treatment

In order to obtain the necessary physical properties the bombs must be heat treated after the forging operations are completed. This is done by placing them in a furnace and heating up to about 1,650 deg. F. This temperature is held between 10 to 15 mins. to allow the bombs to soak. They are then removed and quenched in cold water to 80 deg. F. The heat-treating cycle requires about ½ hr. They are then drawn by heating up to 900 deg. F. and cooled in air.

Machining and Finishing

After the heat-treating operation the bombs are thoroughly shot-blasted to remove all scale and any slight surface defects. The nose and tail are faced-off cold with a power shears and the bomb now has its final shape and dimensions.

It is now ready for the machining operations which consist of preparing the nose and tail for fuze and tail assemblies. The nose is drilled and reamed, then tapped and threaded; the tail is machined in much the same manner for the tail assembly.

With the machining done the two suspension lugs are welded to the outside of the bomb body. Each one is electric-arc welded by hand about one-third the distance from the ends of the bomb. Two beads of weld are laid around the lugs for maximum strength. The suspension lugs are given a tough pull test which exceeds many times the weight of the bomb. The test is necessarily severe because the suspension lugs in service must withstand very high stresses imposed upon them when hanging from a bomber during flight maneuvers in combat, particularly in dive bombing.

For identification purposes, a thin gage steel plate upon which are placed various data is spot welded on the tail of the bomb.

Surface finishing the demolition bombs is an important step. They are first cleaned inside and out with a degreasing compound to remove the machining oil and dirt in preparation for painting. Before paint is applied the surface is thoroughly inspected for compliance with the requirement that the surface should be smooth and free from chips, seams, laps, etc. Particular attention is paid to the bomb cavity, since it is here that a defect might cause a premature explosion.

Following the inspection, the outside of the bomb is painted with olive drab paint, and the interior with an acid-proof ammunition paint. It is important that the entire inside surface be completely covered with the acid-proof paint to prevent a chemical action on the steel from the explosive charge which might cause a premature explosion.

The bomb is then given a final inspection to check the finish; the rear plug is put on; a shipping plug is screwed into the nose to keep out dirt and the bomb is ready to ship for loading.

Physical Tests

The only tests required other than the radiographic examination of one out of every ten bombs, are two sets of tensile tests—one set from each of two bombs taken from every new lot manufactured.

One of the specimens is taken so that the gage section is as near as possible to the point where the ogival nose meets the cylindrical body of the bomb. The other is taken 180 deg. from the location of the first specimen. These bars are pulled to destruction and must come up to the physical requirements as mentioned in the early part of the article.

Welded Vs. Forged Vs. Cast Construction

No conclusive comparisons can be drawn between the weld method of fabricating demolition bombs and the casting and forging processes. The welded bomb is still relatively new and the method described in this article has not yet been put on a full production line basis. Until such a time as it is, any comparisons will be more or less speculative. Nevertheless there are a few obvious points worth considering.

At the present time the casting method of fabrication is not being employed in the manufacture of demolition bombs for the United States. It is probable that the casting method will not be utilized as long as our forging and welding capacity is large enough to fulfill the demand.

Weld methods of construction produce a more uniform product. The plate is cut to exact dimensions and can be rolled to close tolerances. Wall thickness is uniform throughout the cylinder, and the nose and tail wall thicknesses can be easily controlled.

In casting and forging the control is not so accurate. The heavy forging equipment necessary wears comparatively rapidly and requires careful attention to maintain the specified finish dimensions. Casting, with its molds, cores and auxiliary equipment requires considerable care to produce bombs which are uniform in section as well as weight.

In both forging and casting there is a considerable waste of metal. This is not true of the welded bomb in which there is no excess metal involved.

There are, of course, certain precautions that must be observed with welded bombs. The critical factor is the welding operation itself. For efficient production the welding must be done rapidly by automatic machines, but fortunately these constantly produce near-perfect welds. On the other hand, weld repairs are costly and time consuming and must be avoided for a successful operation of this process.

In summary, the welded demolition bomb is superior in many respects to other methods of fabrication. This is especially interesting in view of the fact that it was developed primarily as a means for merely supplementing other methods of manufacture in order to increase bomb productive capacity.

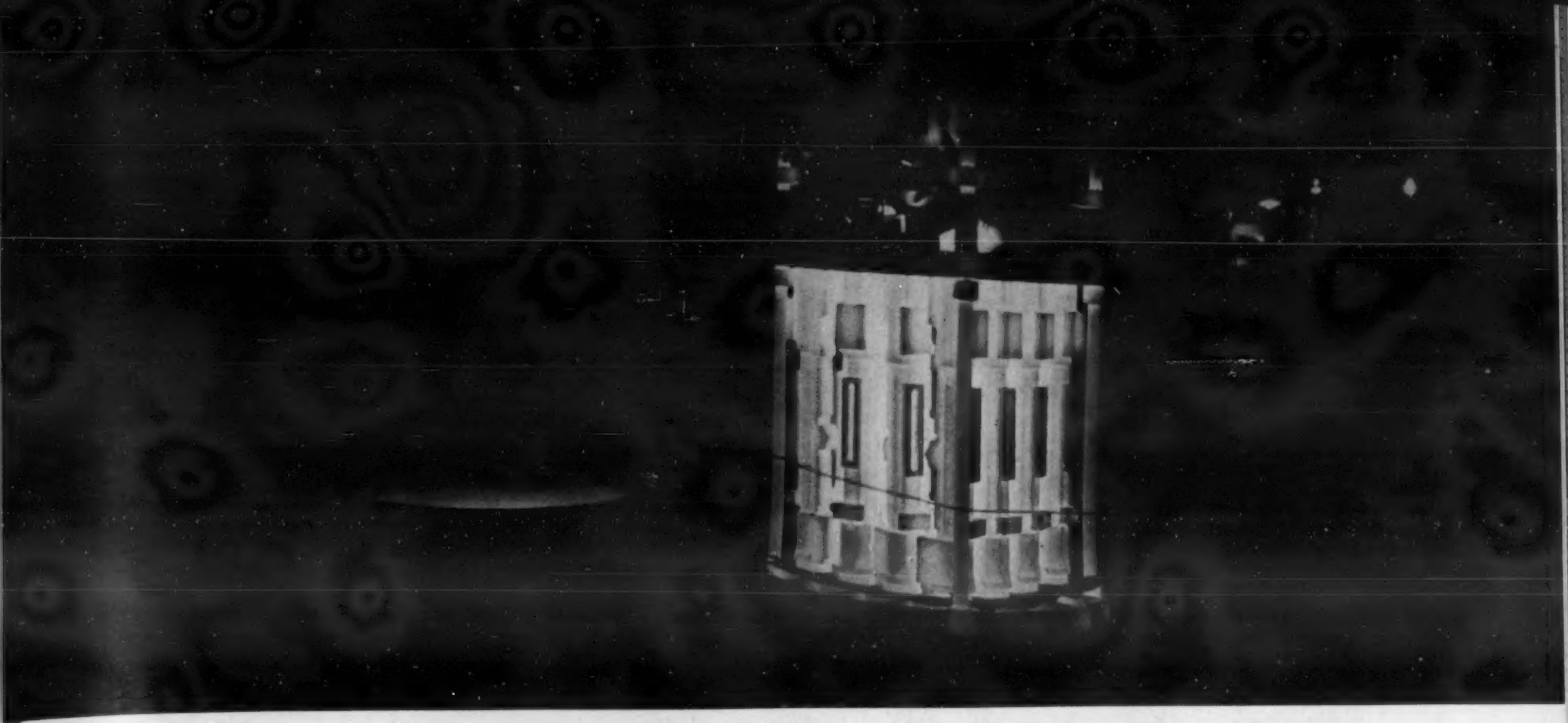


Fig. 1—Fixture carrying 12 heavy (126 lbs. each) gun forgings leaving a forced-convection furnace after a 1650 deg. F. normalizing treatment.

High-Temperature Forced-Convection Furnaces

An outstanding and welcome metallurgical engineering trend of the last two years has been the widening application of 100 per cent forced-convection furnaces designed and built especially for high-temperature work—annealing, hardening, normalizing, nitriding, etc. In the face of the general commercial "impression" and the specific technical dogma that the field for convected air furnaces, with all their advantages, ends at 1300 deg. F., one furnace manufacturer in particular succeeded in designing and merchandising a furnace that—within certain clear-cut limitations—has pushed the heat treating efficiency of forced-convection up to the environs of 1750 deg. F., and thereby speeded and simplified war production in scores of shops. From this viewpoint alone the development represents a straightforward achievement in technical pioneering.

This article is based on inspection by the author of several installations of this one make of high-temperature forced-convection furnace and discussion with its users or examination of their correspondence with its manufacturer concerning the furnace. The article attempts to present not only the performance-advantage of the furnace according to these users' experience, but to cite certain of its limitations as well.

by FRED P. PETERS

Managing Editor

IT IS AXIOMATIC that for maximum uniformity in batch heat treating either the work or the heating medium must be "turbulent." This had been amply demonstrated by the superlative performance and commercial popularity of hundreds of forced-convection tempering furnaces in use before the war. Said the authorities who revised Bullens-Battelle's "Steel and Its Heat Treatment" in 1938 (John Wiley & Sons, page 415): "The circulation of the heating medium is one of the outstanding accomplishments of recent years. It not only leads to striking results in uniformity but also to notable savings in time and fuel."

Although made with particular reference to low-temperature (tempering-range) work, such statements and the principle behind them ought to be equally true of *high-temperature* (hardening-range) applications. Heating by convected air brings a constant and generous amount of heat to each part even in relatively close-packed arrangements; heating is therefore relatively uniform and efficient, and it is not necessary to spread the work out over a large area or

WARTIME ENGINEERING ACHIEVEMENTS

to treat each piece individually to achieve this result.

More than 163 successfully operating installations of one such high-temperature, forced-convection furnace (Lindberg Engineering Company's "Super-Cyclone") are current testimony that convected-air heating in the high-temperature range is more than just a theoretical boon, but is an actuality that is giving war-production heat treating a tremendous boost in certain types of work. And whatever the merits of any possible controversy over "who-done-it-first?" (there are other brands of high-temperature convection furnaces on the market) the pioneering achievement in recognizing this field as one in need of special attention, in designing several furnaces specifically for such work, and in overcoming the technical drawbacks to large-scale application of the idea clearly belongs to the group of engineers who developed the furnaces described in this article.

The advantages of forced circulation furnaces for high-temperature work are nominally the same as for low. (1) The striking uniformity of heating achieved by passing the heating medium through and around the charge keeps distortion at a minimum and assures uniformity of properties from part to part: the low-distortion features eliminates most or all of the time, labor or material-waste involved in subsequent straightening or grinding of heat treated parts. (2) Space is saved—or for the same space, greater production achieved—because the charge can be stacked "in three dimensions," instead of having to be spread out in one layer as is necessary when parts are heated by radiation. (3) Time and labor are often saved in loading and unloading, since the entire charge of several parts can be loaded at once, and removed and quenched together, instead of one-by-one.

The advantage of quicker heating by convection, as compared to radiation, for the lower-temperature range does not *necessarily* hold at high temperatures, since heat transfer by radiation becomes increasingly efficient as the temperature rises. In fact, this knowledge was one of the factors that tended to limit the use of convection to lower temperatures. The best commercial heat treating, however, is more than just the best heat transfer—it is uniformity of heating: maximum utilization of free-space; highest production rates; lowest labor, time and equipment costs; and several other operating effects. And for many jobs the superiority of convection-type equipment in *these* respects heavily outweighs any possible inferiority in heat transfer efficiency at the higher temperatures.

To put it simply, the fact that a given single part might have to be exposed to heat a shorter time with radiation heating than with convection heating to be thoroughly soaked should, in good engineering be overruled by the fact that one can often load a convection furnace of the same size or cost to 4 or 6 or 10 times the load permissible in a radiation furnace and still keep the heating reasonably uniform.

The experience of several users of the Lindberg high-temperature convection furnace demonstrates that the net engineering advantage of the overall idea are far greater than the possible negative effect of one scientific principle as a minor component thereof.

Heat Treating Gun Forgings

In the heat treating field there are many jobs that cannot be hardened in the usual way without getting bad distortion, owing to the massiveness of the part or differences in section thickness within it. Typical of these is the normalizing, hardening and drawing of a certain type of heavy gun forging, which so far has not been heat treatable without serious distortion by any other method except forced-convection heating. In addition, the convection method has telescoped time and space on this work, since the time required to heat treat a given number of forgings has in effect been reduced because a larger number of parts can be simultaneously treated in the area available for the heat-treating equipment. An extra advantage in this (and similar cases) is the possibility of normalizing and then subsequently hardening and tempering in the same furnace.

The Lindberg Super-Cyclone used for this work (like all the others described in this article) a 100 per cent forced convection, pit-type unit. Heat is generated *in a separate chamber* away from (and completely insulated with respect to) the work chamber, but within the furnace. The heated air is transferred from the heat chamber by a high-speed fan and forced under pressure into the work chamber and downward through all parts of the charge, after which the circulation path is completed back to the fan.

The gun forgings, made of S.A.E. 3450 steel, weigh 126 lbs. each and are normalized at 1560 deg. F. Fig. 1 shows a fixture carrying a charge of 12 gun forgings that has just come from a Lindberg Super-Cyclone at normalizing heat; the total weight of this charge is 1512 lbs. Heating (including heating-up and soaking) time in the new furnace is 2½ hrs.

After being allowed to air cool to 400 deg. F., the forgings are charged—on the same fixture—back into the Super-Cyclone, heated to 1500 deg. F., held for 1 hr., and then oil-quenched down to 400 deg. F. Still on the same fixture, the work goes back to the same furnace once more, this time for a 4-hr. draw at 1075 deg.

The previous method of normalizing these forgings was by means of a radiation-type box furnace which could handle only 5 pieces per heat. The capacity

was so limited because of the difficulty of loading and unloading, and also because piling the parts one on top of another would result in an exceptionally dense charge that would be difficult to heat in the box-type furnace. Time to heat the work to 1560 deg. F. was 5 hrs. in the old furnace, which included 1 hr. for soaking.

Thus, only 5 forgings are normalized in 5 hrs. with the older type of equipment, as compared with 12 forgings being turned out in only 2½ hrs. in the forced-convection furnace. This amounts to a production increase of almost 5 times over the former method.

Forgings treated in the box furnace always required straightening, whereas the work handled in the convection furnace required no straightening whatsoever; warpage is always less than 0.001 in. With the box furnace, 2 men were required to handle the forgings one-by-one in loading and unloading the furnace for each operation. With the new furnace, the operator loads the fixture away from the furnace, and then lowers it into the furnace by means of a hoist or crane. As pointed out earlier, the fixture remains loaded for the normalizing, hardening, and drawing operations and can be quickly and easily handled by one man with a hoist.

One problem encountered with use of the new furnaces has been the fixtures. In the first place, the success of convection heating is absolutely dependent on proper separation and spacing of the parts in their arrangement in the furnace; once recognized, this problem ceases to be serious since it then becomes a matter of common-sense fixture design. At the same time, however, the relatively massive fixtures must be quenched *with the work* for the method to be fully advantageous, and this new factor means that special attention must be paid to the quenching operation through enlarged tank capacity, circulation and cooling of oil, etc. Again, once these precautions are taken by the furnace manufacturer and the user, there is no serious difficulty.

One definite limitation introduced by the fixture is that the method is not applicable to water-quench jobs, since each water-quenching would ruin the fixture for future use.

Tubular Aircraft Parts

Another interesting application of the new furnace is for the hardening and drawing of tubular aircraft parts; for this work, the convection equipment provides faster production through heavier loading; a very large space-saving; and elimination of much handling labor and time. These parts, which come in some 6 or 8 different sizes, are made of S.A.E. X4130 steel. Among those sizes used in large quantities is a piece 36 in. long and 1-7/16 in. in diameter (¼ in. wall), weighing approximately 14 lbs. each.

Over 80 of these pieces are loaded vertically in an alloy fixture for hardening (total charge, over 1100 lbs.). The usual temperature is from 1600 to 1650 deg. F., although this is varied according to the analysis of the particular load being handled. The time required to bring the charge up to heat is ¾ hr., and soaking time 1 hr.

Following the quench, the parts go back into the same furnace for drawing. Here they are held at 1000 deg. F. for 1 hr. and come out with a Rockwell "C" hardness of 25 to 31. Distortion is almost completely eliminated—it has never been necessary to straighten this work. According to the company doing this work, a box furnace, roughly comparable in size to the Super-Cyclone now in use, handles but 40 of these pieces and requires a heating time of 2 hrs. The parts, of course, have to be loaded and quenched one at a time. At least 15 min. would be required to load 40 pieces into the heated work chamber. Heating time as mentioned above would be 2 hrs., and 40 min. would be required to quench the work—again, each part singly. The total time therefore required to handle 40 parts would run 2 hrs. and 55 min.—and for 80 parts it would be 5 hrs. and 50 min.

Now compare: Turning out 80 units with the new furnace requires 15 min. to load (away from the heat), 45 min. to heat and soak, and 5 min. to quench for a total of 65 min. The forced-convection equipment therefore gives a production increase of over 5 times, turning out 80 parts in 65 min. as compared with 5 hrs. and 50 min. required to turn out the same amount of work in a box-type furnace. In addition, these figures do not take into consideration the savings due to the elimination of straightening time, which is one of the biggest cost items to be considered.

Larger pieces, 3½ ft. long and weighing 125 lbs., are handled 16 at a time (total charge, 2000 lbs.). These are preheated to 1325 deg. for 2 hrs. before being raised to 1625 deg., where they are held for 45 min. The total preheat and soaking time is 4¾ hrs. After the quench, the work goes back to the same furnace, where it is drawn at 875 to 900 deg. F. for 3 hrs. The resulting hardness is 380-400 Brinell.

Large Ring Gears

Typical of the savings in time and labor gained by the ability to switch from virtual one-by-one handling of stock in radiation-type box furnaces to several-at-once treatment in the new convection-type units is the hardening of large spiral-bevelled ring gears, as now carried out in a shop using several Super-Cyclones on various jobs.

One variety of these gears is made of S.A.E. 2340 steel and the gears weigh approximately 100 lbs. each, have a 26 in. O.D. and an 18 in. I.D. They are loaded 12 at a time (total charge, 1200 lbs.)

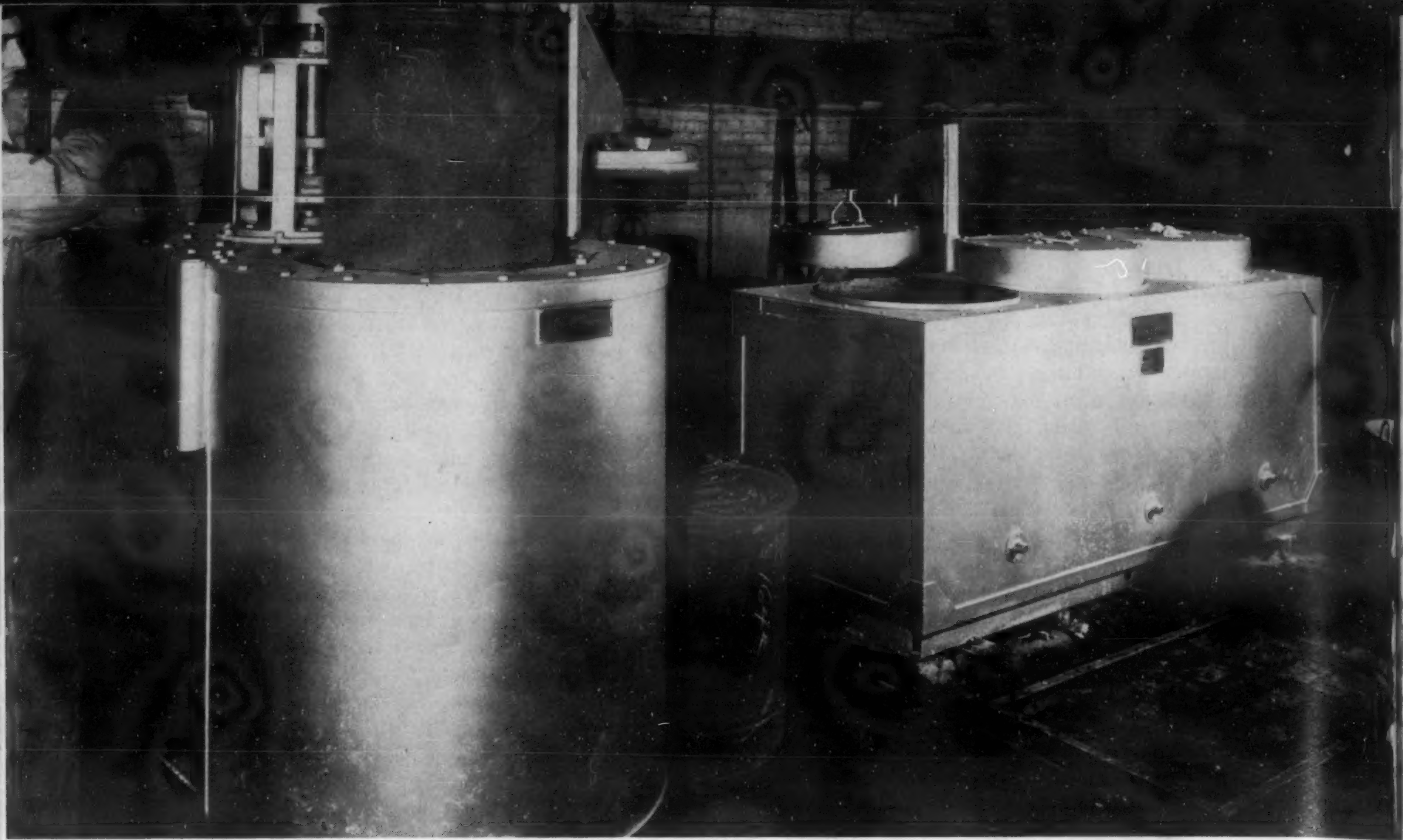


Fig. 2—Loading a high-temperature forced-convection furnace with a charge of tools to be annealed at 1500 deg. F.

Fig. 3—A load of heated tools being transferred to the special cooling unit as part of the annealing cycle in a high-temperature forced-convection furnace.

into the new furnace where they are heated to 1470 deg. F. and then oil-quenched. Heating time is 1½ hrs. Following the quench, the gears go back *into the same furnace* where they are drawn for 4 hrs. at 400 deg. F.

Production in the overall cycle is thus 12 heats in about 6 hrs. Distortion is held to 0.015 in. and all gears meet specifications for roundness and flatness.

These gears were previously handled one at a time in a box furnace. This was necessary as the work distorted so badly (0.100 to 0.150 in. out of round) that it had to be straightened hot from the quench. Heating time was 3 hrs., and scaling would result if the gears remained in the furnace longer than this time to await quenching and straightening operations. Production in this way was in the neighborhood of 1½ gears in about 6 hrs. (as compared with 12 gears in 6 hrs. by the new system).

To take advantage of the chamber capacity of the box furnace, which would actually hold 5 gears, it would be necessary to have 5 men quench simultaneously and immediately straighten the gears on 5 different straightening presses.

This shop is completely sold on the forced-convection furnaces for treating massive parts that require "babying" to minimize and correct distortion in treating and handling with radiation-box furnaces. They use the new furnaces for work that has been completely described in Lindberg's advertising and which, therefore, need be only mentioned here—the heat treating of 20-lb. S.A.E. 4140 worm gears, 100 at a time, with a 3-fold increase in production over box-furnace practice and elimination of more than 90 per cent of the post-hardening straightening formerly required.

In addition, they have found the new furnaces peculiarly well suited to annealing and spheroidizing cycles that entail considerable cooling-down and holding (such as heat to 1700 deg. F., cool at a certain rate to 1450 deg. F., soak for so many hours, cool at a certain rate to room temperature, etc.), which had to be tediously carried out in batch-type radiation

furnaces, but can be safely done with dispatch in the convection units.

On the other hand, this shop also handles large amounts of very small tools and parts, which, it was pointed out, are definitely not suited to processing in convection-type equipment. The success of convection heating depends on free access of the heating medium to all parts of the charge, which must therefore be spaced in the fixture; with tiny parts (bolts, nuts, screws, clips, small springs, etc.), the time and trouble necessary to string them up individually on a fixture would obviously be prohibitively great.

Annealing Tools and Wrenches

Another interesting example of production speed-up through the use of these new furnaces is provided by the experience of the Armstrong Brothers Tool Co., Chicago, where a Super-Cyclone is employed for annealing wrenches and tools following forging and before subsequent machining operations.

The furnace is designed for operation up to 1750 deg. F., and has a work-chamber 22 in. in diameter and 26 in. deep. Heat is generated electrically by tubular elements in the separate "heat-chamber." (Most of the Lindberg high-temperature convection furnaces are fuel-fired, however.) Fig. 2 shows the furnace being charged.

For this installation, a triple-chamber cooling unit has been provided, into which the work can be placed after it has been brought up to heat (see Fig. 3). This leaves the furnace itself free to handle additional heating charges, which will also be cooled in one of the cooling chambers.

In designing the cooling unit, provisions were made for special vents at the rear of each chamber, which can be connected with an extra heating unit to provide heat that will reduce the speed of cooling in the event that future requirements might call for a slower cooling rate. Both the furnace and the cooling unit can be used with or without controlled atmosphere, depending on the job being done.

An average charge of typical work to be annealed would weigh a minimum of 1500 lbs., exclusive of the work basket. The heating cycle for such a charge would run from 2½ to 3 hrs. at 1500 deg. F. and 9 hrs. in the cooling chamber. The user states that his production is "much greater" with this compact convection unit than with the radiation-type furnaces formerly employed.

The job as now carried out requires the attention of one man for an average of less than 10 min. of each 3-hr. period; this involves merely lowering the work basket (which is automatically loaded by a conveyor) into the work chamber. After the completion of the heating cycle, a hoist is utilized to transfer the work basket from the furnace to the cooling chamber, where it remains for 9 hrs.

Heating uniformity is stated to be very good, all parts of the charge being evenly and rapidly heated to the same temperature; reports as to machinability also show results to be excellent, since hard spots are never encountered.

Advantages and Limitations Summarized

Some of the practical advantages and limitations of 100 per cent forced-convection furnaces for high-temperature work, as revealed by the foregoing case histories, may be summarized in conclusion.

The best field for the new furnaces, and one in which they seem to provide spectacular improvement in production and great savings in labor, handling and space charges, is for treating massive parts of varying section that by conventional methods require individual handling to avoid distortion. Similarly, the new furnaces shine brightly wherever distortion due to non-uniform heating is a problem.

For such work convected-air furnaces of the type discussed provide uniform and fast heating of large batches of stock. Distortion is limited or eliminated and subsequent straightening and grinding largely obviated. Handling-labor and costs are usually sharply reduced, and considerable space is invariably saved; the manufacturers of the Super-Cyclone, for example, estimate that their furnace will require no more than 1/3 the floor space needed by other equipment to handle the same production, and the experience of the users mentioned in this article bears that out.

An additional advantage is the possibility of using the same furnace for hardening and tempering—something that is economically impossible to do with radiation furnaces. Allied to this is the special suitability of the convection furnaces for annealing and spheroidizing cycles that involve cooling-down at controlled rates and holding at progressively lower temperatures.

The convected-air furnaces are, of course, not suitable for "bright" hardening, annealing, normalizing, etc., and for most work of this type controlled atmosphere furnaces are usually indicated. Nor can the convection equipment be economically employed for heating tiny parts that are ordinarily closely packed for heat treating.

In using the new furnaces, special attention must be paid to fixture design and to quenching conditions, but this is usually a minor operating problem in any case.

The new furnaces are often more expensive, as-installed, than other equipment of equivalent capacity. One or 2 of the furnaces discussed in this article, for example, usually do as much work as *several* box furnaces that cost in the aggregate 2/3 as much. But the cost savings and improvement in production normally realized far outweigh the initial cost comparison.

LETTER TO THE EDITOR

Copper-Bearing Steel

To the Editor: Mr. F. Eberle, in his article "Copper-Bearing Steel for Heavy Fabrication," April issue, proposes "the maximum amount of copper permissible in steel without introducing difficulties in weldings appears to be 0.80-1.00 per cent."

This article was of interest to me as, 2 yrs. ago, I had occasion to assist in the investigation of the cause of hot-cracks in a copper-bearing steel resulting from welding.

The welds were made with low-carbon welding rod on ¾-in. plate of rimmed steel, containing 0.25 per cent Cu. The cracks were first noticed on test coupons, which were given a reverse-bend test for welds in a bending jig. The cracks which "opened up" were in the copper-bearing steel plate about ½-in. away on either side of the weld, and were discolored blue indicating formation at high temperatures. Some of the test coupons showed copper sweated out in small globs along the cracks, others did not. However, some unbent test coupons were given a macro-etch and the presence of cracks alongside the weld confirmed. Subsequent microscopic examination indicated the copper-bearing phase in the grain boundaries, and the cracks to be intergranular as pointed out by Mr. Eberle.

Further tests indicated that the cracks were a result of a combination of the internal stresses set up by welding and the low-melting point of the copper-bearing phase in the steel plate. In welding copper-bearing steel sheets where the stress relieves itself by strain (buckling), 0.3 per cent Cu probably has no effect; but in fairly thick plate, copper-bearing steels, containing as little as 0.25 per cent Cu, are definitely affected by welding technique. To obviate this type of hot cracking in the base metal, it is best to limit the heat input during welding by using small beads rapidly laid down by an electric arc.

Apprentice-Learner School
Canal Zone

WALLACE J. AWGUN
Instructor in Metallurgy

In reply to Mr. Awgun's communication, I wish to state that we have welded in our fabrication steel plates 1 in. thick and over, containing up to 0.30 per cent Cu, for many years without having experienced a single failure due to the presence of this element. We have also made experimental welds with steel containing up to 0.50 per cent Cu and subjected them to guided jig bend tests without noticing the phenomenon related by Mr. Awgun. However, these bend tests were made with machined specimens, that is, after removing the surface layer. According to our experience, the low-melting copper-bearing phase appears only in the surface of the steel under the scale due to preferential oxidation of iron. It may well be possible that under certain circumstances stress cracks are initiated by these surface cracks. When such stress cracks occur at temperatures at which scaling takes place, the copper-bearing phase may appear under the scale of the oxidized cracks. I am inclined to believe that the weld failure described by Mr. Awgun was not primarily caused by the presence of copper in the steel and that the latter was an incidental and contributing phenomenon.

—F. EBERLE

A COUPLE OF CHUCKLES

A Moral

One of the staff of Battelle Memorial Institute sends us the following:

> Yesterday afternoon, I left a note on my waste paper basket which read as follows: "Janitor, please empty pan of cores on floor near window." This morning the note below was lying in the empty pan.
>
> J. H. J.
>
> "So Sorry Gents, could not locate any cores. The fellow that ate the fruit must have ate the core also—but I did empty the pan which contained the brickbats.
>
> Your Janitor"

Moral—Don't use technical terms for non-technical readers!

Wants To Aid the War Effort!

We reproduce the following letter, which came to the editor's desk recently, addressed to "The Chemical Catalogue Co., 419 Fourth Ave., at 29th St., New York," as of decided interest—from an enthusiastic Mr. H. W. of Houston, Texas, who wants to aid our war effort. Metallurgically and for other reasons, it is "a honey."

Dear Sirs;

I would like to get in touch with a Man, not a sigaret smoker, if he smokes a cigar or a pipe, all right, and dont get drunk.

A Man that is up to date on the Electric Smelting of Tin Ore.

I expect to build a Smelter to Smelt Tin Ore by Electricity, to first get it so it will work perfect, say to handle 25 Ton of Ore in 8 hours, and after it is where there are no downfall in any way to cause trouble, or delay, to increase the Plant to where 50 Ton of pure Tin can be turned out in 24 hours.

To handle everything by power, which will be Electric, no wet system in any way, except the washing and drying of the Ore.

Will make my own Power Plant with plenty of Power.

If we are going to win this War, WE must pull togather, will you give me a helping hand, in every way possible by sighting me to any information, that will realy help me.

Remember: The dollar is not everything in this World, Sociability is the highest degree, Help Each Other.

In 1910 I was treveling down a River a lone in South America on a raft, J turned over twice, and lost $360.00 worth of grub in the bottom of the River which Hundreds of feet deep, I managed to save a can with some flower in, as the can was near empty, and had a tight lid on, which make it flote, and I poled it in. I had 20 Dollor Gold pieces in my belt, but coulden eat them, but lived on Flour and Water 4-¾ days.

METALLURGICAL ENGINEERING news

Equipment • Finishes • Materials • Methods • Processes • Products
Alloys • Applications • Designs • People • Plants • Societies

Insulated Welding Electrode Holder

To speed production welding operations, a new insulated welding electrode holder with detachable "stinger" has been introduced by *Jackson Products,* 3265 Wight St., Detroit.

The female section of the cable connector is permanently soldered to the cable lead and remains in the insulated handle (A). The detachable jaw section — the "stinger" (B) — is snapped into the female section by a quick twist of the operator's wrist and is ready for business. The actuating cam mechanism that locks

male and female sections together is shown at (C). The lock is said to be positive and may be quickly disengaged.

This holder eliminates waste of time in changing cable connections, and does away with dangerous loose cable ends kicking about when the "stinger" end is detached. When necessary, the handle and the cable may be pulled through a small hole and the "stinger" then connected, saving time and cable extensions.

Each welder is responsible for his own holder. Disconnecting the "stinger" at the end of a shift, he may turn it in for inspection and servicing, thus extending holder life. The holder is called the Jackson "Quik Trik."

• Improvements have been made in Series 2800 "Vernier-Set" timers, which control machines and process operations in many fields, including die casting machines, automatic quenching and continuous furnaces. Four augmented features are: Bakelite terminal block, leaf-spring contact, timer and load circuits wired independently, and flaminol and special flexible wiring throughout. They are made by the *Automatic Temperature Control Co., Inc.,* 34 East Logan St., Philadelphia.

Remote Control for Welders

A new remote control unit is now a standard feature of all welders offered for sale by *Hobart Bros. Co.,* Troy, Ohio. It is protected from breakage by a metal pull-out handle over the control dial and by cushion springs on the back of the porcelain rheostat.

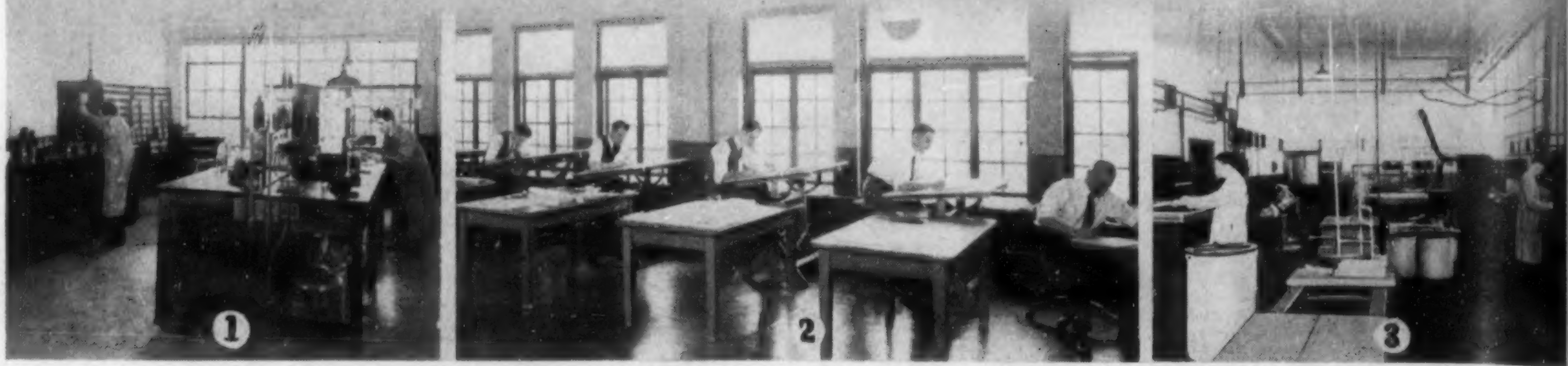
Welding heat should be increased with coated electrodes in changing from flat positions to vertical or overhead positions, and vice versa. Often the operator is tempted to save himself repeated trips between work and machine. With remote control, 100 steps of fine volt-amperage adjustment are within reach of the operators hand.

The large outer control dial, shown in the picture, is the field rheostat which controls the differential compounds, while the remote control unit adjusts the open circuit voltage. With this Multi-Range

dual control dial 1,000 combinations of voltage and current are possible.

(More news on page 650)

UDYLITE



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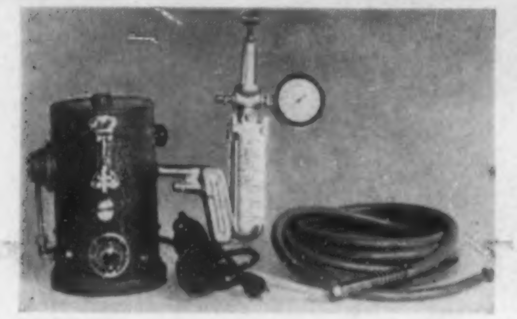
A new low cost, self-contained and portable metal atomizer, capable of spraying



any neutral alloy with a melting temperature up to 600 deg. F. for protective coating, reproducing likenesses, etc. is offered by *Alloy-Sprayer Co.*, 2040 Book Bldg., Detroit.

It is good for making templates, spotting or checking dies, reproducing molds, etc. The sprayer illustrated has 12 cu. in. capacity, with electrical elements for heating the metal in the heavily insulated pot. Temperature control is variable over 100 deg. through a rheostat switch knob, with a thermostat keeping temperature constant.

● A widespread increase in use of carbide dies and mandrels for tube drawing has been noted by *Carboloy Co.*, Detroit. They draw tubing as small as 0.013 in. (for hypodermic needles) and as large as 3½ in. Chief advantages of carbide as compared with steel and chrome are: Longer die and mandrel life, higher drawing speeds and lower cost-over-life of die.

Prizes for Compressed Air Ideas

Describing the successful application of compressed air to increase the speed of producing cartridge cases 500 per cent, A. W. Lancaster, Orillia, Ont. received first prize of $200 in a contest of the *Compressed Air Institute*, New York. There were 3 second prizes of $100 each and 10 third prizes of $50 apiece for papers showing many striking advantages of compressed air in industry and defense.

The winner of the first prize told how an air-operated mechanism, which locates the cases in the cartridge case machine and ejects them, increased production and reduced operator fatigue. The next improvement was a dual control air valve at the bed of the machine to replace a hand lever on the headstock of the lathe which turned on and off the compressed air. By now, production was five times the original.

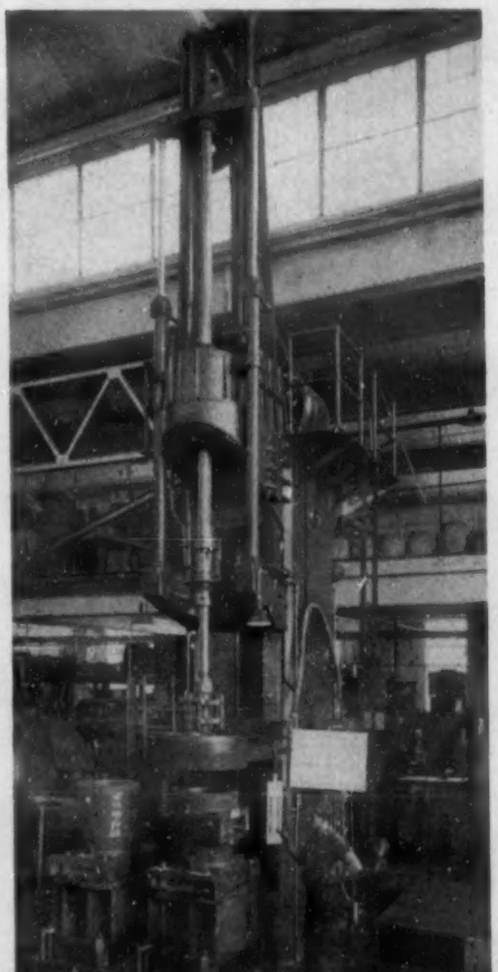
Some of the other prize winning ideas were as follows: Compressed air was used in laying a mat of asphalt on roads, being shot through a nozzle. Water was freed from iron by passing a strong current of air through it, this taking out carbon dioxide, causing iron to separate out. Forge hammers were powered with compressed air. Coke screenings were shot into brick kilns to heat all bricks evenly. Compressed air can be substituted for oil in transformers.

Hones Cylinders with 26-inch Bore

Previously there have existed machines that would hone a cylinder up to a 16-in. bore. Now a machine which will hone a cylinder with bore as large as 26 in. across has been built by *Cooper-Bessemer Corp.*, Mt. Vernon, Ohio.

This is probably the largest vertical cylinder-honing machine ever constructed. It stands 20 ft. high. It is the first time an electric control has been applied to this type of machine. There are three methods of finishing cylinders: Boring, grinding and honing. By boring, it is almost impossible to maintain tolerances, states Cooper-Bessemer.

Grinding above a certain size is difficult because of the overhang of the grinding wheel on the spindle.



The new honing machine described can handle a cylinder 26 in. in diam. and 6 ft. long.

Silver Brazing Alloy Is Superior

A 2-in. solenoid core wound on a light weight brass spool is part of the control mechanism for firing guns. By modern methods, the brass end-piece of this spool is fitted on a brass tube and joined permanently by a low temperature silver brazing alloy.

The previous method, using a high temperature base metal brazing alloy, distorted the spool. With silver alloy, a temperature of 1175 deg. F. only is required. The joint is stronger than the brass itself, states *Handy & Harman*, 82 Fulton St., New York.

Magnetic Separators for Two Purposes

Two magnetic separators, so popular now in intensive salvage campaigns, are announced by the *Dings Magnetic Separator Co.*, 509 E. Smith St., Milwaukee. One, the high intensity Roche type, is for reclamation of very valuable alloy steels from grinding fluids. The other, the high intensity magnetic pulley type, is designed for reclamation of steel and iron from foundry and steel mill slag dumps.

In the first, coolant fluid from grinder is fed to the magnetic separator. Suspended in the fluid are particles of abrasives, also of alloy steels. The magnetic portion is pulled along by the main conveyor belt over a series of alternating pole magnets. A water spray continually washes the material as it goes from pole-to-pole, all non-magnetics being washed from the product. The magnet is very ruggedly designed.

In the second separator, four pole pieces extend completely around the circumference of the magnetic pulley. Between pole pieces are wound magnet coils, protected by heavy bronze coil covers, which are an exclusive feature. It is said that at slag dumps the separator installations have paid for themselves in several months.

● A magnetic welding clamp has been designed by the *Stearns Magnetic Mfg. Co.*, Milwaukee. In welding, plates are drawn to a level alignment by the magnet, with the edges brought flush against the perfect surface of the magnet. It is an improvement over hand or mechanical means.

Film Protects Delicate Metal Surfaces

To protect highly polished surfaces against rust corrosion, grease, finger markings, etc. the *United States Stoneware Co.*, Akron, Ohio, has brought out "Tygon Tempro-Tec." Liquified, it forms a stable, non-adhesive film when dried. Either crystal clear, or of transparent colored formulations for ready identification purposes, it is applied by brush, dip, spray or roller coating.

It is not affected by oil, grease, gasoline, etc. It peels off as a complete film without injury to the surface beneath. It is

handy to use during handling, shipping and installation and is good for machine tools, bearing surfaces, and various metals in many forms.

Electrode Provides Faster Welding

A new arc welding electrode which permits up to 100 per cent faster fillet welding has been introduced by the *Lincoln Electric Co.*, Cleveland. Called "Fleetweld 11," it is designed for the "Fleet-Fillet" technique of arc welding.

It is fast flowing and gives deeper penetration of metal into the root of the joint. It is of the shielded arc type and heavily coated to exclude oxides and nitrides from the weld.

"Fleet 11" welded in 35 sec. a joint that required 1 min., 17 sec. to weld with conventional electrodes and procedure. It decreases fatigue of the operator, costs and amount of electrode used per foot of weld. As to the last, a test showed 0.26 lbs. of electrode per foot against 0.37 lbs. by the usual method.

Designed to complete a weld in one pass, it is made in 18-in. lengths and 3/16 and ¼ in. diameters, packed in 50 lb. cans.

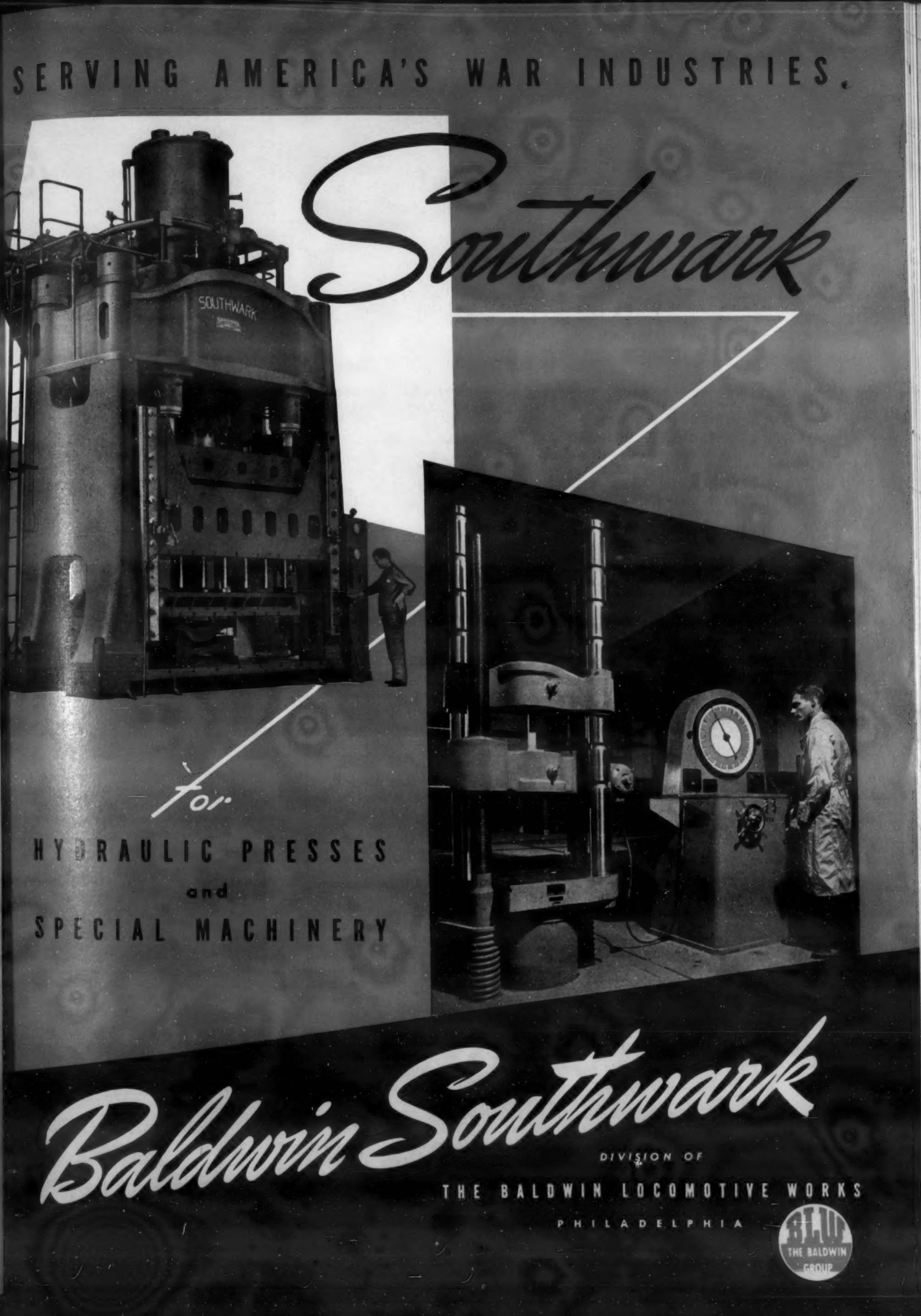
● Straight and 90 deg. angle swivels for making oil, grease, air and other line connections between stationary and revolving, oscillating and other moving surfaces are among new lines brought out by *Trabon Engineering Corp.*, 1814 E. 40th St., Cleveland. Due to ball bearings, these swivels turn freely at any pressure without binding.

Mica Topped in Brass Furnaces

Use of Fiberglas tape insulation in the place of mica as coil insulation in the primary coil of induction-type brass furnaces at the *Western Cartridge Co.*, East Alton, Ill., provided for 50 per cent reduction in cost, increased production of 3000 lbs. per shift per furnace, and the number of man-hours required to install it was less than half that for mica.

The 38 furnaces at Western Cartridge have a sleeve-shaped form of ceramic material that retains the helical flat copper coil. Fiberglas tape is spiraled between turns in the coil to form a double helix composed of alternate layers of copper and Fiberglas tape, insulation preventing short circuiting.

Fiberglas allowed increase of furnace temperature sufficient to produce five pours of 1500 lbs. each during each 8-hr. shift, as against three pours, 1500 lbs., with mica.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News of Metallurgical Engineers

Fred P. Peters, managing editor of METALS AND ALLOYS, has been appointed to the Industrial Salvage Section, Conservation Division, WPB, Washington, as a special advisor. He will also continue his work on the staff of this magazine, dividing his time equally between the two assignments.

Dr. Charles H. Frelton becomes head of the Department of Metallurgy, Montana School of Mines, Butte, Mont., for the duration, succeeding Professor John P. Spielman, who is now an officer in the U. S. Air Corps. Dr. Frelton has been connected with several mining and metallurgical schools and is the author of two well-known textbooks, one of which is "Principles of Metallurgy."

Frederick A. Pease, formerly with Metals Disintegrating Co. and for the past year a consulting metallurgical engineer with headquarters at Maplewood, N. J., has opened a new laboratory in Newark, N. J., for carrying on a wide variety of metallurgical services.

Dr. George B. Waterhouse has been transferred from the War Production Board to the Office of Lend-Lease Administration, Washington, where he will act as special consultant on iron, steel and other metals.

George T. Jones has been appointed chief metallurgist of the Homestead Steel Works of Carnegie-Illinois Steel Corp. *John W. Price, Jr.* has been appointed assistant chief. Mr. Jones, after several years with Allegheny Steel Co., joined Carnegie-Illinois as a metallurgist in March 1937. Mr. Price joined the Homestead Works in the same year after several summers' employment at the Lorain plant of the National Tube Co.

F. Lloyd Woodside has become president of Park Chemical Co., Detroit. For six years he has been connected with the metallurgical research division of the Climax Molybdenum Co. He started his industrial career with Studebaker Corp. in 1912. All these years he has specialized in carburizing and heat treatment of steels.

F. C. Todd has joined Battelle Memorial Institute, Columbus, to do research in industrial physics, having been on the faculty of Pennsylvania State College.

Chester W. Smith, a specialist in electroplating during the past eight years, has become research chemist in the alkali division, Detroit Rex Products Co., Detroit. He was formerly chief chemist with J. C. Miller Co.

John S. Stanier has been appointed superintendent of hot and cold strip mills at the Campbell plants of the Youngstown Sheet & Tube Co. He was graduated from Lehigh University in 1923 and the following year served as night superintendent of the West Penn Steel Co. Later he was made metallurgist, then became general manager. In 1928 he joined the Newton Steel Co. and in 1933 affiliated with the Youngstown Sheet & Tube Co. In 1936 he was appointed superintendent of the cold strip and sheet mills.

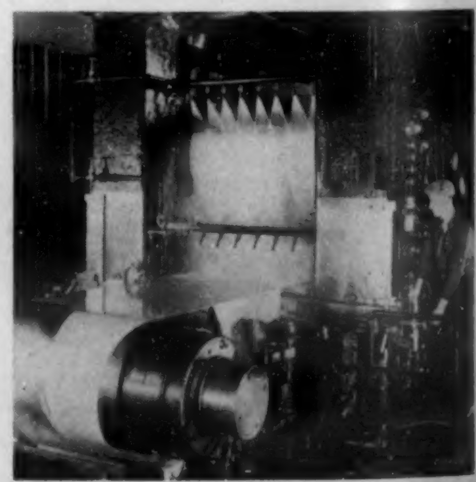
D. A. Sherick has become production metallurgist of the Welded Tube Div., Babcock & Wilcox Co., Alliance, Ohio, having formerly been with the Weirton Steel Co., Weirton, W. Va. He was graduated from Case School of Applied Science.

M. L. Samuels has become research metallurgist with Babcock & Wilcox at Beaver Falls, Pa., having been with Battelle Memorial Institute, Columbus. He is a graduate of Peabody College and Harvard Graduate school.

Edwin L. Smalley, president of the Hevi Duty Electric Co., died in Milwaukee, August 29th, at the age of 65. As a pioneer in the electric heat treating furnace industry, he was the holder of a considerable number of furnace patents.

Nozzle Throws Flat, Fan-Like Spray

For cooling rolls and descaling billets and plates in the steel industry and many other purposes, Rex spray nozzles have proved effective. Made by the *Chain Belt*



Co., 1600 W. Bruce St., Milwaukee, the nozzle throws a flat fan-like, hard-hitting spray that removes dirt or grit from most irregular surfaces. The spray is so forceful that it produces an extremely thin line of impact which amounts to a sharp cutting action. The nozzle is non-clogging.

Slants and Plants

News of the establishment of new production records now meets with no more enthusiastic response than a yawn. What would raise eyebrows would be a new record for slowness, such as a century plant that blossomed only once in two centuries. However, we will risk one more speed record—in fact 421 records. That is the number made in all mines and plants of *Republic Steel Corp.*, 170 altogether, between December, 1940 and Aug. 1st, 1942.

August shipments of finished products by the *United States Steel Corp.* were the largest in history for that month, or 1,788,650 net tons. Shipments for 1942 through Aug. 31st were 14,057,906 tons, a new record compared with 13,473,209 tons for the same period in 1941.

The name of *Tubular Products, Inc.*, U. S. Steel subsidiary, has been changed to *Tubular Alloy Steel Corp.* in order to be more descriptive of the products of the company. Tubular early this year acquired the existing plant of the National Tube Co. at Gary, Ind. to produce seamless tubing of alloy and stainless steel. Outlets will be aircraft, motor parts, bearings, tank tractors, oil refineries and others.

Celebrating its second major plant expansion since Jan. 1st, along with 100 per cent subscription in war bonds, the *Cooper-Bessemer Corp.*, Mt. Vernon, Ohio, staged a housewarming party for employees and guests Aug. 29th in the new $300,000 addition to the foundry in Mt. Vernon. Early this year the 109-year old corporation completed a large addition to its Pennsylvania diesel engine plants. A unique feature of the new core shop is the method of handling the large volume of sand. A spur track runs along the side of the building with hoppers underneath so that sand may be dumped from freight cars and hoisted when needed from the hoppers into the sand muller. At the housewarming core ovens served as booths for refreshments.

There are records for this and records for that. *Cramp Shipbuilding Co.*, Philadelphia, has received recognition in an unusual way—for being foremost among shipyards of the U.S.A. in rapid and efficient unloading of freight cars and releasing these for urgent needs elsewhere. In less than two years it has unloaded 2,530 carloads of materials without a single car being held beyond the free time allowed in the demurrage tariffs. A committee, including Joseph B. Eastman, director of the Office of Defense Transportation, praised the company "for an outstanding and valuable achievement."

Skillfully-trained women are gradually outnumbering the men employees in the small shell department of *Oil Well Supply Co.*, U. S. Steel subsidiary. As the enthusiastic public relations officer writes it, apparently having secured his information at first hand, "a growing production army of attractive young women attired in slacks" is milling and threading high explosive projectiles. The women enjoy two 10-minute rest periods each shift. They relax in a recreation room with lounge chairs and plenty of the latest magazines.

Courses for Women in Metallurgy

Advanced training for women in chemical engineering and metallurgy will be instituted at Columbia University, New York, terms beginning Sept. 28th and Feb. 1st, 1943, with a speed-up session starting May 31st, 1943. The courses are open to college graduates who have majored in chemistry.

Metallurgy will be taught by Dr. Eric Jette, Columbia professor of metallurgy. Classes will equip women to examine metals under the microscope, perform physical tests to determine their properties and to study means by which these properties can be controlled to make metals suitable for various services.

Extensive work will be given in the theory and techniques of physical metallurgy, strength of materials, physical chemistry in its application to metals and their production for use and pyrometry.

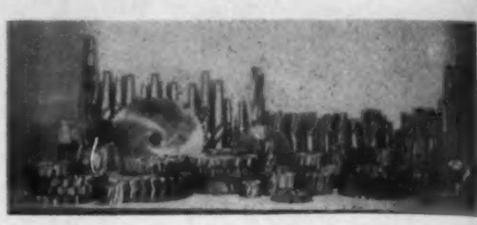
New Tool-Reclaiming Process

A reclamation-welding process, known as "Suttonizing," differs from many in that in most cases subsequent heat-treating is necessary. Neither in this new process is it necessary to anneal before making the reclamation. The process is especially adapted to teeth, flutes, tangs, shanks, and fractures on milling cutters, broaches, drills, large-sized Ingersoll type ball and end mills, line reamers, cutting tools for lathe, planer and shaper and special shaped forming tools.

This method also precludes possibility of dimensional distortion sometimes met in heat treatment. Thus, a broach, heat-treated after reclamation, would be practically impossible to hold in line. Sponsors of "Suttonizing" claim that the process differs from insert methods insofar that the adding of alloys results in deposits becoming integral parts of the tools.

Because of much attention to ingredients of the welding rod, it is claimed that "Suttonizing" combines the cutting qualities of conventional high-speed steel with abrasive resistant qualities, about equal to the typical tungsten carbides. The deposits are as easy to grind as conventional high-speed steel; they are homogeneous and will match or excel the original hardness of the salvaged tool.

To avoid heat-treatment after welding, there is an ingenious preheating before



welding. In many cases, high-speed steel tools faced by this method results in three times as much production on one regrind, as is experienced with a new tool.

The process was named after Thomas Sutton, welding engineer, and is controlled by *Welding Equipment & Supply Co.*, 223 Leib St., Detroit.

The accompanying photo depicts various broken and useless tools that will be placed back into operation by "Suttonizing."

• To make acidity and alkalinity (pH) tests of all types of baths in the plating room, *La Motte Chemical Products Co.*, Baltimore, Md., has developed a new outfit. It applies to baths of chlorides, nickel content, ferrous iron, acid copper, cyanide copper, acid zinc, cyanide zinc, cadmium, brass and bronze solutions, all used in electroplating and electro-typing.

Speedy Aluminum Heat-Treating Furnace

An aluminum heat-treating furnace capable of quenching 8,000 lbs. of castings in 25 sec. has been installed in a Cincinnati plant by the *Despatch Oven Co.*, Minneapolis, and is believed to be the first of its kind. A speedy material handling system consists of a series of rollers mounted in the loading section, on the top and in the interior of the elevator quench-cage and on the bottom of the furnace work chamber. All are carefully aligned and form a level roadway.

In operation, a processed load is withdrawn by air winch from furnace onto elevator cage, then dropped quickly into quench bath. The waiting load is then pulled directly into furnace, passing over the quench bath on the series of rollers.

The furnace is of the radiant tube convection type with indirect gas heater. Heat flow from side ducts is both vertical and horizontal and passes outward through recirculating ducts.

• The "Tandem Timer" is unusually versatile in production departments, laboratories and for life testing of electrical apparatus. It permits practically any timing sequences desired. It is a control unit with two individual and variable plug-in type-timing elements. Automatic reset features make a continuous, as well as a single cycle of operation. It is made by *Industrial Timer Corp.*, 113 Edison Place, Newark, N. J.

"Torrid", the Despatch Heat Wizard, Speaks to Metal Congress . . .

Despatch Heat Wizard Wins Metal Show O.K.

Reveals Secrets of Successful Despatch Furnaces, Ovens

Cleveland Auditorium, Oct. 12—A fiery, energetic little heat wizard belonging to Despatch Oven Company today told Metal Show delegates new facts about Despatch furnaces.

Striding carefully back and forth on a heavy asbestos platform, the impudent, sizzling little scamp won approving applause from the audience.

Balanced Heaters, Fans, Ducts

"You've wondered", he said, "how Despatch furnaces and ovens manage to have so much oomph. How it is that they are so flexible and speedy—how overshoot and temperature lag are eliminated. How they can process with such exceptional uniformity and operate so efficiently and economically".

He paused, smiled as closer members of his audience removed their coats, fanned themselves.

"Well, the answer is this: Every single Despatch furnace or oven is engineered. This means that our big, tough, high-velocity fans, our oversized heaters, our adjustable ports in the recirculating duct system are balanced carefully and to the most delicate degree by Despatch engineers who know heat dynamics and can apply their knowledge to fit every furnace or oven because they have had 40 years of practical experience."

Despatch's Complete Line of Furnaces and Ovens

In reviewing Despatch's accomplishments, Torrid laid emphasis on heat treating furnaces for aluminum and magnesium castings, forgings, billets, sheets and shapes for aircraft parts, engine parts, for tanks, etc., furnaces for shell cases that are accomplishing wonders with steel and brass. Also tempering and hardening furnaces, stress relief furnaces and armor plate heat treating furnaces, as well as ovens for speedy and precision core baking, mold drying.

Stop in at the Despatch Booth No. A-415 at the National Metal Congress, and let's get acquainted. I will be flanked by photo murals of Despatch furnaces and ovens where I am now working producing more and better war materials.

After the congress adjourns, you will find me working wherever you see a Despatch foundry oven or furnace.

A special invitation is extended to everyone unable to attend our show this year to call or write Despatch for interesting and helpful bulletins and engineering services.

Torrid

DESPATCH
OVEN COMPANY MINNEAPOLIS

Meetings and Expositions

SOCIETY OF AUTOMOTIVE ENGINEERS, semi-annual meeting. New York, N. Y. Oct. 7-8, 1942.

ELECTROCHEMICAL SOCIETY, fall meeting. Detroit, Mich. Oct. 7-10, 1942.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Inst. of Metals, and Iron & Steel Divisions. Cleveland, Ohio. Oct. 12-14, 1942.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Rochester, N. Y. Oct. 12-14, 1942.

AMERICAN SOCIETY FOR METALS, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

AMERICAN WELDING SOCIETY, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

NATIONAL METAL CONGRESS AND EXPOSITION. Cleveland, Ohio. Oct. 12-16, 1942.

WIRE ASSOCIATION, annual meeting. Cleveland, Ohio. Oct. 12-16, 1942.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual meeting. Springfield, Mass. Oct. 16-17, 1942.

AMERICAN PETROLEUM INSTITUTE, annual meeting. Chicago, Ill. Nov. 9-13, 1942.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting. Cincinnati, Ohio. Nov. 16-18, 1942.

NATIONAL CHEMICAL EXPOSITION. Chicago, Ill. Nov. 24-29, 1942.

• Added aids to radiography are Kodak Liquid X-ray Developer (and ditto, Fixer), these two being equal to Eastman X-ray processing chemicals in powder form. They are made by *Eastman Kodak Co.*, Rochester, N. Y.

Light Alloys Division of A. F. A.

A Light Alloys Division of the American Foundrymen's Association has been formed in recognition of the increasing demand for aluminum and magnesium castings. The present non-ferrous division will become the Brass and Bronze Division.

The first step in the organization of the Light Alloys Division will be appointment of an advisory committee. Several prominent metallurgical engineers have already volunteered their services. Others interested may apply to R. E. Kennedy, Secretary, *American Foundrymen's Association,* 222 W. Adams St., Chicago.

Contents

Introduction

The National Metal Congress this year is announced as "far different from any held in the 24-year history of this big event." The theme or motto of the Congress this year is education—devoted solely to increasing the production of war products. The Congress will take place in Cleveland, Oct. 12 to 16 inclusive. While the war effort may interfere to some extent with the complete success of the event, a large attendance at both the technical feasts and the exposition is fully assured.

The Participating Societies

Four technical societies, as in the past, cooperate in the Congress: The American Society for Metals, the sponsor for the whole event; the two metals divisions of the American Institute of Mining and Metallurgical Engineers, the American Welding Society, and the Wire Association.

The usual large number of technical papers, lectures and discussions have been prepared by leading men in the four participating societies.

A special feature will be 25 A.S.M. War Production Sessions, similar to the Defense sessions at the last Congress in Philadelphia. Prominent authorities in Government and industry will speak briefly at these sessions and off-the-record on the 25 topics listed elsewhere in this preview—all speakers will act later as members of an information panel for open discussion.

The Exposition

Exhibitors from at least 250 companies will participate in the annual exposition held in the spacious Cleveland Public Auditorium. The exposition will be open daily from noon to 10:30 p.m. except on Thursday when it will close at 6:00 p.m.

Lectures

The feature event among the lectures is always the annual Campbell Memorial Lecture. It is to be delivered this year by John Chipman, professor of metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

At 5:00 p.m. on each day of the Congress, J. P. Gill will deliver lectures on "Tool Steel."

In General

Each of the participating societies hold their technical sessions at the hotels where their headquarters are located. On other pages will be found the tentative technical programs of each society.

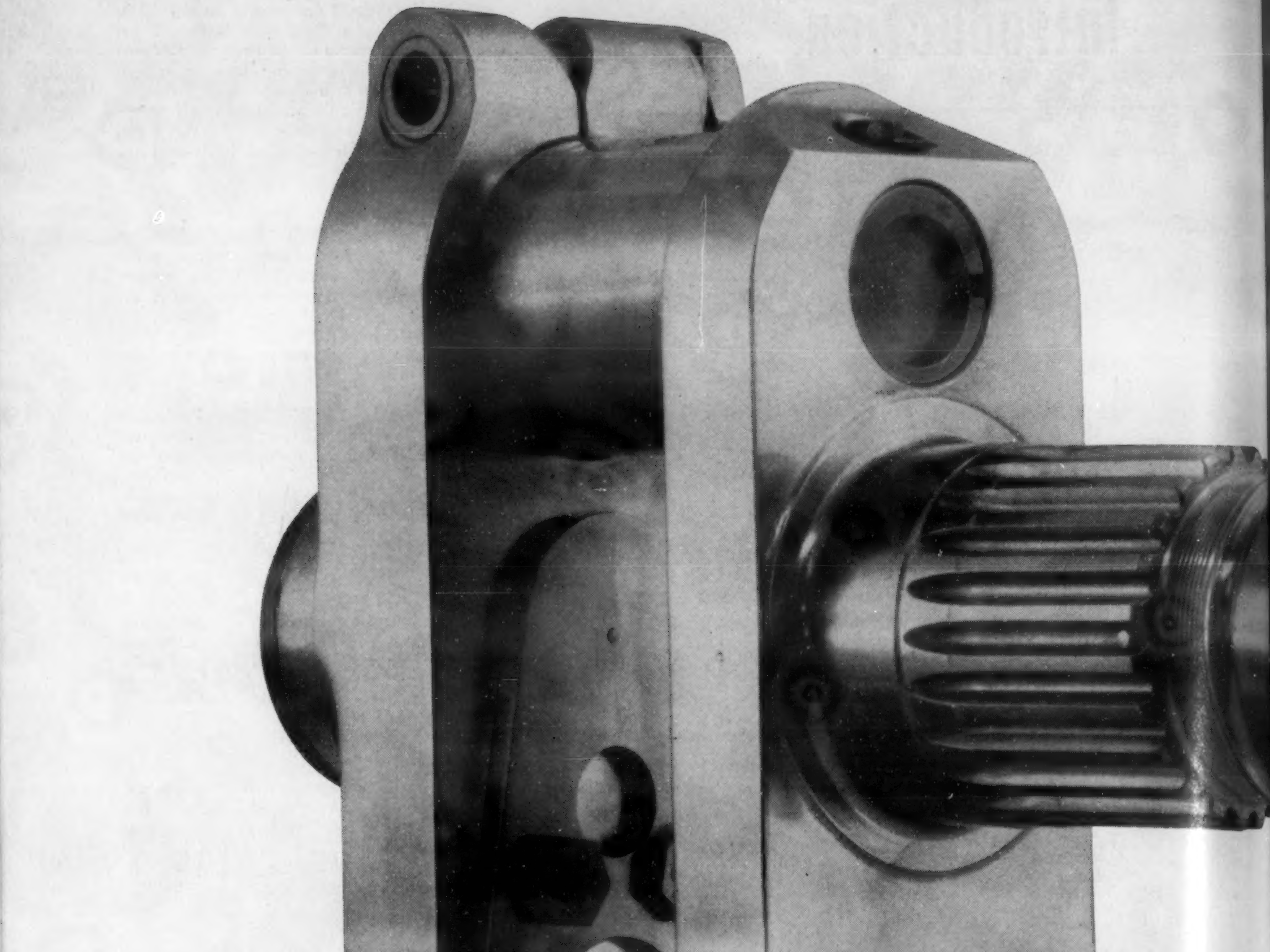
Bradley Stoughton
President
A.S.M.

Herbert J. French
President-Elect
A.S.M.

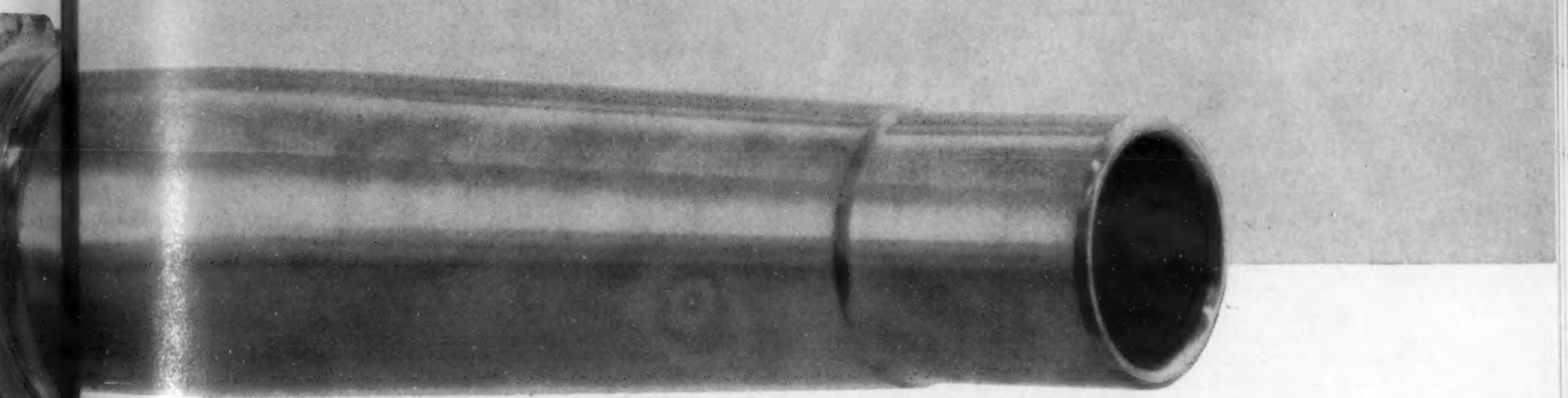
Francis B. Foley
Treasurer
A.S.M.

John Chipman
Campbell Memorial
Lecturer

Benjamin F. Shepherd
Sauveur Achievement
Award



What's the most important half second in the life of a crankshaft?



YOU'RE looking at one of the sweetest pieces of precision engineering that ever stirred a craftsman's heart. Accurate as the balance wheel of your watch, this airplane engine crankshaft will soon be helping some pilot show the enemy what American men and machines can do.

However, in the split-second in which the final grinding operation on the shaft was completed, had the operator taken off just 0.001 inch more than the minimum diameter specified for the bearing, for instance, the shaft would never have seen action at all. Its value would have been reduced to scrap. And the staggering total of man and machine hours which had gone into it up to that point would have been worth absolutely nothing.

Can you find a single operation in war production where so much is at stake as in the final grinding process? Because of the key role it plays in war output, the grinding operation is one of the first places to check for ways to conserve materials, effort and time.

Make certain that your grinding machines are being operated with the utmost possible care. Make certain too that you are using the right grinding wheel for the particular job at hand. It is a *Weapon of Production* and should be properly used for maximum effectiveness.

Manufacturer's recommendations should be carefully followed on wheel speed, work speed, rate of infeed, wheel traverse, proper coolant and wheel grading (grit, grade and bond). Only the correct balance of these several factors will insure maximum production.

You are cordially invited to visit us at Booth C-122
National Metal Congress Exposition
Cleveland Auditorium, October 12-16.

COMPANY, NIAGARA FALLS, N.Y.

Sales Offices and Warehouses in New York, Chicago, Philadelphia, Detroit, Cleveland, Boston, Pittsburgh, Cincinnati, Grand Rapids

Tentative Technical Program of the

American Society for Metals

The technical program of the American Society for Metals is always regarded as one of the leading technical features of the National Metal Congress.

About 40 papers are scheduled for this year's program, to be delivered at 12 different sessions—about 30 per cent less than those prepared for the program last year in Philadelphia. All of these sessions will be held during the mornings of each day, similar to the procedure a year ago. The afternoons are set aside for the Increased Production Sessions which are to be participated in by leading Government officials and industrialists, and metallurgical engineers. At these sessions, 25 of them, special practical subjects will be discussed off the record. The morning technical sessions will be held at the society's headquarters, the Hotel Statler; the afternoon sessions will take place in the Public Auditorium.

The Campbell Memorial Lecture, the technical highlight of the Congress, will be delivered Wednesday morning, Oct. 14, in the Ball Room of the Statler Hotel, by John Chipman, professor of metallurgy, Massachusetts Institute of Technology. Educational lectures on "Tool Steel" will be delivered each day at 5:00 p.m. by J. P. Gill, chief metallurgist, Vanadium Alloy Steel Co.

The annual banquet is scheduled for Thursday evening, Oct. 15, at the Statler Hotel. Several awards will be presented at this dinner. The Albert Sauveur Achievement Award will go to Benjamin F. Shepherd of the Ingersoll-Rand Co. and past president of the A.S.M. To John C. Garand, inventor of the Garand automatic rifle, will go a special award.

The tentative technical program for the A.S.M. convention is as follows:

Hotel Statler, Headquarters of ASM

MONDAY MORNING, OCT. 12

"Effect of Elements in Solid Solution on Hardness and Response to Heat Treatment of Iron Binary Alloys," by C. R. Austin, Pennsylvania State College.

"Third Element Effects on Hardenability of a Pure Hyper-Eutectoid Iron-Carbon Alloy," by C. R. Austin, Pennsylvania State College, W. G. Van Note, North Carolina State College, and T. A. Prater, Pennsylvania State College.

"The Ar Range in Some Iron-Cobalt-Tungsten Alloys," by W. P. Sykes, General Electric Co.

SIMULTANEOUS SESSION

"The Effect of Hardness on the Machinability of Six Alloy Steels," by O. W. Boston and L. V. Colwell, University of Michigan.

"Carburizing Characteristics of 0.20 Per Cent Carbon Alloy and Plain Carbon Steels," by G. K. Manning, Republic Steel Corp.

"The Metallography of Galvanized Sheet Steel Using a Specially Prepared Polishing Medium With Controlled pH," by D. H. Rowland and O. E. Romig, Carnegie-Illinois Steel Corp.

SIMULTANEOUS SESSION

"Bursting Tests on Notched Alloy Steel Tubing," by G. Sachs and J. D. Lubahn, Case School of Applied Science.

"Notcher Bar Tensile Tests on Heat-Treated Low Alloy Steels," by G. Sachs and J. D. Lubahn, Case School of Applied Science.

"Stress-Strain Measurements in the Drawing of Cylindrical Cups," by E. L. Bartholomew, Jr., Massachusetts Institute of Technology.

"Fatigue Strength of Normalized and Tempered Versus As-Forged Full Size Railroad Car Axles," by O. J. Horger and T. V. Buckwalter, Timken Roller Bearing Co.

TUESDAY MORNING, OCT. 13

"The End-Quench Test: Reproducibility," by Morse Hill, Wright Field.

"The End-Quench Test: Hardenability of Aircraft Steels and its Representation," by Morse Hill, Wright Field.

"Hardenability Control of A One Per Cent Carbon Steel," by G. R. Barrow and Gilbert Soler, Timken Roller Bearing Co.

SIMULTANEOUS SESSION

"The Alpha Iron Lattice Parameter as Affected by Molybdenum, and an Introduction to the Problem of the Partition of Molybdenum in Steel," by F. E. Bowman, R. M. Parke and A. J. Herzig, Climax Molybdenum Co.

"The Effect of Molybdenum on the Isothermal, Subcritical Transformation of Austenite in Eutectoid and Hyper-Eutectoid Steels," by J. R. Blanchard, R. M. Parke and A. J. Herzig, Climax Molybdenum Co.

"The Effect of Molybdenum on the Rate of Diffusion of Carbon in Austenite," by J. L. Ham, R. M. Parke and A. J. Herzig, Climax Molybdenum Co.

(Continued on page 678)

(Continued from page 674)

SIMULTANEOUS SESSION

"The Method of Thin Films for the Study of Intermetallic Diffusion and Chemical Reactions at Metallic Surfaces," by H. S. Coleman and H. L. Yeagley, Pennsylvania State College.

"On The Location of Flaws by Stereo-Radiography," by James Rigbey, Ford Motor Co. of Canada.

"The Fluorescent Penetrant Method of Detecting Discontinuities," by Taber de Forest, Magnaflux Corp.

WEDNESDAY MORNING, OCT. 14

ANNUAL MEETING OF THE AMERICAN SOCIETY FOR METALS

The 1942 EDWARD DE MILLE CAMPBELL MEMORIAL LECTURE, by John Chipman, Massachusetts Institute of Technology.

THURSDAY MORNING, OCT. 15

"A Metallographic Study of the Formation of Austenite From Aggregates of Ferrite and Cementite in an Iron-Carbon Alloy of 0.5 Per Cent Carbon," by T. G. Digges and S. J. Rosenberg, National Bureau of Standards.

"Influence of Initial Structure and Rate of Heating on the Austenitic Grain Size of 0.5 Per Cent Carbon Steels and Iron-Carbon Alloy," by T. G. Digges and S. J. Rosenberg, National Bureau of Standards.

"The Mechanism and the Rate of Formation of Austenite from Ferrite-Cementite Aggregates," by G. A. Roberts, Vanadium-Alloys Steel Co., and R. F. Mehl, Carnegie Institute of Technology.

SIMULTANEOUS SESSION

"The Tantalum-Carbon System," by F. H. Ellinger, General Electric Co.

"Influence of Strain Rate on Strength and Type of Failure of Carbon-Molybdenum Steel at 850, 1000 and 1100 Deg. F.," by R. F. Miller and G. V. Smith, U. S. Steel Corp., and G. L. Kehl, Columbia University.

"Rupture Tests at 200 Degs. C. on Some Copper Alloys," by E. R. Parker and C. Ferguson, General Electric Co.

SIMULTANEOUS SESSION

"Corrosion of Water Pipes in a Steel Mill," by C. L. Clark, Timken Roller-Bearing Co., and W. J. Nungester, University of Michigan.

"A Study of the Iron-Rich Iron-Manganese Alloys," by A. R. Troiano and F. T. McGuire, University of Notre Dame.

"The Induction Furnace as a High Temperature Calorimeter and the Heat of Solution of Silicon in Liquid Iron," by John Chipman and N. J. Grant, Massachusetts Institute of Technology.

THURSDAY EVENING, OCT. 15

A.S.M. Dinner—Statler Hotel Ballroom.

FRIDAY MORNING, OCT. 16

"The Hardening of Tool Steels," by Peter Payson and J. L. Klein, Crucible Steel Co. of America.

"The Kinetics of Austenite Decomposition in High Speed Steel," by Paul Gordon and Morris Cohen, Massachusetts Institute of Technology, and R. S. Rose, Vanadium-Alloys Steel Co.

"The Tempering of Two High-Carbon High-Chromium Steels," by Otto Zmeskal, Illinois Institute of Technology, and Morris Cohen, Massachusetts Institute of Technology.

SIMULTANEOUS SESSION

"Some Aspects of Strain Hardenability of Austenitic Manganese Steel," by D. Niconoff, Republic Steel Corp.

"The Precipitation Reaction in Aged Cold-Rolled One Per Cent Cd-Cu: Its Effect On Hardness, Conductivity, and Tensile Properties," by R. H. Harrington and L. E. Cole, General Electric Co.

"The Effect of Moderate Cold Rolling on the Hardness of the Surface Layer of 0.34 Per Cent Carbon Steel Plates," by Harry K. Herschman, National Bureau of Standards.

SIMULTANEOUS SESSION

"The Metallography of Commercial Magnesium Alloys," by J. B. Hess and P. F. George, The Dow Chemical Co.

"Study of Inverse Segregation Suggests New Method of Making Certain Alloys," by M. L. Samuels, A. R. Elsea and K. Grube, Battelle Memorial Institute.

"Effects of Various Solute Elements on the Hardness and Rolling Texture of Copper," by R. M. Brick, Yale University, D. L. Martin, General Electric Co., and R. P. Angler, Handy & Harman.

EDUCATIONAL COURSE

5:00 P.M. Daily

"TOOL STEELS," by J. P. Gill, Vanadium-Alloys Steel Co.

War Production Sessions

Subjects to be discussed at 25 A.S.M. war production sessions of the National Metal Congress and War Production Edition of the National Metal Exposition, has been announced by W. H. Eisenman, secretary of the A.S.M. and managing director of the Exposition.

"These sessions will be patterned after the successful 'Defense Meetings' at last year's Congress," Mr. Eisenman said. "Outstanding authorities in government and industry will speak briefly, informally and off the record on important phases of these 25 topics, with all speakers acting later as members of an Information Panel for open discussion."

The following subjects will be discussed in the 25 sessions:

Doing More with What We Have in Increasing Production from Open-hearth Plants.
Increasing Yields of Electric Furnaces (Electric Steel Manufacture).
Problems Associated with the Large Expansion of the Steel Foundry Industry.
Doing More with What Alloys We Have by Using NE Steels (two sessions).
Doing More with Low Alloy and Carbon Steels by Use of Special Additions in Steel Manufacture ("Intensifiers").
Doing More with Available Tool Steels.
Speeding the Job by Better Production Heating for Softening (Hot Working & Annealing).
Speeding the Job by Better and Faster Production Hardening.
Manufacture and Heat Treatment of Magnesium Castings.
Fabrication of Aluminum Sheet.
Making Better Use of Secondary Metals.
Segregation, Collection and Reclamation of Scrap.
On Deep Drawing Problems (two sessions) I. Brass; II. Steel.
Speeding Production by Improved Metal Cutting Practice (two sessions).
Interpretation of Magnaflux and Other Surface Inspection Tests.
Use and Interpretation of Radiographic Inspection.
Current Achievements in Powder Metallurgy.
Training and Handling Inspectors.
Getting By with Low Tin Alloys.
Salvage of Broken Tools and Maintenance of Equipment.
Employee Training in Metal Working Departments (Fabrication).
Methods and Materials for Surface Protection.

These war production sessions will be held in addition to the regular technical sessions of the four participating societies. More than 100 papers will be presented at these regular sessions.

Tentative Technical Program of the

Metals Divisions of the A. I. M. E.

The metal divisions of the A.I.M.E. are cooperating in the National Metal Congress this year for the 15th consecutive year. The usually excellent technical program has been prepared. Over 25 papers have been scheduled for the 7 sessions at the headquarters, the Hotel Statler They deal with both the practical and theoretical aspects of ferrous and non-ferrous metallurgy.

A feature of the week's technical program will be a symposium on rare and precious metals which is scheduled for all day Tuesday, Oct. 13.

The usual joint annual dinner of the Iron and Steel and the Institute of Metals Divisions will be held at the Statler, Tuesday evening, Oct. 13. It is expected that Earle C. Smith may be back from abroad in time to be the principal speaker.

The tentative technical program is as follows:

Institute of Metals Division

MONDAY AFTERNOON, OCT. 12

COPPER-BASE ALLOYS:

"Phase Diagram of the Copper-iron-silicon System from 90 to 100% Copper," by A. G. H. Andersen, Met. Engr., Oakdale, N. Y., and W. A. Kingsbury, Phelps Dodge Corp.

"Internal Friction of an Alpha Brass Crystal," by Clarence Zener, Assoc. Prof. of Physics, Washington State College; now at Watertown Arsenal.

"Note on Some Hardness Changes That Accompany the Ordering of Beta Brass," by Cyril Stanley Smith, Res. Supvr., War Metallurgy Comm., National Academy of Sciences, National Research Council.

TUESDAY MORNING AND AFTERNOON, OCT. 13

SYMPOSIUM ON RARE AND PRECIOUS METALS

"Rare Metals and the War Effort," by W. P. Sykes, Consultant, Conservation Division, W.P.B.

"The Rare Metals and Why They Are Rare," by R. S. Dean, Asst. Director, U. S. Bureau of Mines.

"The Use of Silver During the Emergency," by R. H. Leach, Vice Pres., and John L. Christie, Metallurgical Manager, Hardy & Harman.

"The Effect of Certain Elements on the Rate of Tarnishing of Silver Alloys," by W. E. Campbell, Research Chemist, Bell Telephone Laboratories.

"Bismuth Solders and Other New Applications of Bismuth," by A. J. Phillips, Supt., Research Dept., American Smelting & Refining Co.

"Elements À La Carte: A Summary of the Status of Artificially Produced Elements and Some of Their Applications," by K. K. Darrow, Physicist, Bell Telephone Laboratories.

"Rare Elements in the Electrical Industry," by Porter H. Brace, Cons. Met., Research Lab., Westinghouse Electric and Mfg. Co.

"Rare Elements in the Glass Industry," by M. B. Vilensky, Chief Met., Owens-Corning Fiberglas Corp.

"Notes on Refractory Metal-Base Compound Materials," by G. G. Goetzel, Metallurgist, American Sinteel Co.

"Time-to-fracture Tests on Platinum, Platinum-iridium, and Platinum-rhodium Alloys," by H. E. Stauss, Research Physicist, Baker & Co., Inc.

WEDNESDAY AFTERNOON, OCT. 14

ALUMINUM, MAGNESIUM, AND LEAD

"The Rate of Precipitation of Silicon from the Solid Solution of Silicon in Aluminum," by L. K. Jetter, Aluminum Res. Lab., Aluminum Co. of America, and Robert F. Mehl, Dept. of Met., Carnegie Inst. of Tech.

"Equilibrium Diagrams and Lattice Spacing Relationships in the Systems Magnesium-tin and Magnesium-lead," by Geoffrey V. Raynor, Inorganic Chemistry Laboratory, The University Museum, Oxford, England.

"Constitution of Lead-rich Lead-antimony Alloys," by W. S. Pellini, Res. Asst., and F. N. Rhines, Member of Staff and Asst. Prof. of Met., Metals Res. Lab., Carnegie Inst. of Tech.

Iron and Steel Division

MONDAY AFTERNOON, OCT. 12

MAGNETITE REDUCTION: CHROMIZING: WELDABILITY

"A Study of Low Temperature Gaseous Reduction of a Magnetite," by M. C. Udy and C. H. Lorig, Battelle Memorial Inst.

"Chromizing of Steel," by I. R. Kramer and Robert H. Hafner, Div. of Physical Met., Naval Research Lab., Washington, D. C.

"Calculated Hardenability and Weldability of Carbon and Low-alloy Steels," by C. E. Jackson and G. G. Luther, Div. of Physical Met., Naval Res. Lab., Anacostia Station.

TUESDAY MORNING, OCT. 13

TENSILE PROPERTIES AND HARDENABILITY

"True Stress-strain Relations at High Temperatures by the Two-load Method," by C. W. MacGregor, Assoc. Prof. of Applied Mechanics, M.I.T., and L. E. Welsh, Engr., Bakelite Corp.

"The Calculations of the Tensile Strength of Normalized Steels from Chemical Composition," by F. M. Walters, Jr., Dir. of Physical Met., Naval Res. Lab., Anacostia Station.

"Effect of Silicon on Hardenability," by Walter Crafts and J. L. Lamont, Union Carbide & Carbon Research Lab. Inc., Niagara Falls, N. Y.

TUESDAY AFTERNOON, OCT. 13

OPEN HEARTH STEEL

"Duplex Process for Manufacture of Basic Open-hearth Steel," by H. B. Emerick and S. Feigenbaum, Metallurgical Dept., Jones and Laughlin Steel Corp.

"The Effects of Tin on the Properties of Plain Carbon Steel," by J. W. Halley, Met., Inland Steel Co.

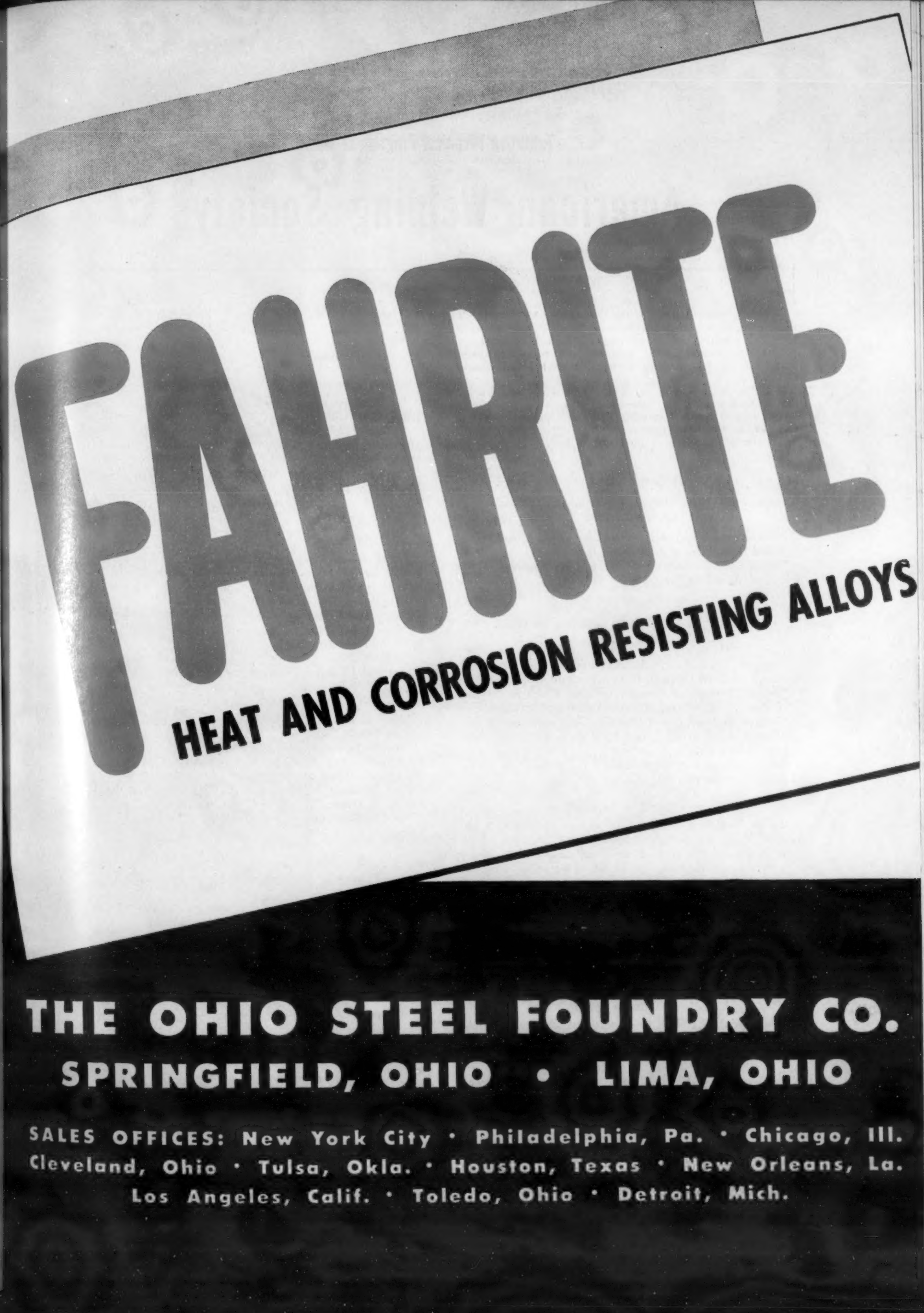
"Cause of Bleeding in Ferrous Castings," by C. A. Zappfe, Res. Met., Battelle Memorial Inst.

WEDNESDAY AFTERNOON, OCT. 14

PHYSICAL CHEMISTRY OF STEEL MAKING

"Silicon: Oxygen Equilibria in Liquid Iron," by C. A. Zappfe, Res. Met., and C. E. Sims, Supervising Met., Battelle Memorial Inst.

"Equilibria of Liquid Iron and Simple Basic and Acid Slags in a Rotary Induction Furnace," by C. R. Taylor, Res. Engr., American Rolling Mill Co., and John Chipman, Prof. of Met., Mass. Inst. of Tech.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Tentative Technical Program of the

American Welding Society

Welding engineers attending the annual convention of the American Welding Society will be able to listen to a technical program of broad scope. Something over 55 papers for delivery at 16 sessions have been tentatively scheduled for the meeting during National Metal Week, Oct. 12 to 16.

All the sessions will be held at the Cleveland Hotel, the headquarters.

The annual banquet is scheduled for Thursday evening, Oct. 15, at the headquarters.

The tentative technical program follows:

MONDAY MORNING, OCT. 12

Session on Training of Welding Operators and Qualifications

"*Training of Welding Foremen,*" by F. H. Achard, Consolidated Edison Co. of New York, Inc.

"*Instruction Methods in Welding Developed by U. S. Office of Education,*" by H. K. Hogan, U. S. Office of Education.

MONDAY AFTERNOON, OCT. 12

Session on Fatigue and Impact

"*Fatigue Strength of Metal Subjected to Combined Stresses,*" by L. H. Donnell, Illinois Institute of Technology.

"*Fatigue Strength of Commercial Butt Welds in Carbon Steel Plates,*" by W. M. Wilson, University of Illinois.

"*Fatigue Tests of Full Thickness Plates with and Without Butt Welds,*" by E. C. Huge and H. J. Kerr, The Babcock & Wilcox Co.

"*Impact Strength of High Alloy Steel Welds,*" by E. C. Chapman, Combustion Eng. Co.

Session on War Production

"*Some Special Applications of Flame Hardening,*" by Stephen Smith, Air Reduction Sales Co.

"*High Quality Welding—Vertical and Overhead Positions with Alternating Current,*" by H. O. Westendarp, General Electric Co.

"*Conservation and Effective Use of Equipment and Supplies for Welding and Cutting,*" by H. Ullmer, The Linde Air Products Co.

"*Welding Gun Mounts,*" by W. B. Lair, York Safe and Lock Co.

MONDAY EVENING, OCT. 12

Motion Picture Films

"*The Inside of Welding*"—Educational film by General Electric Co.

"*The Welding of Aluminum*"—Aluminum Co. of America.

"*Fundamentals of Oxyacetylene Welding*"—Courtesy Navy Department.

TUESDAY MORNING, OCT. 13

Session on Weldability of Steel

"*Cooling Rates as Affecting Weldability,*" by G. E. Doan and R. D. Stout, Lehigh University.

"*Effects of Cooling Rate on the Properties of Arc Welded Joints,*" by W. F. Hess, Rensselaer Polytechnic Institute.

"*Weld Quench Gradient Tests,*" by W. H. Bruckner, University of Illinois.

Session on Aircraft Welding (Fuselage)

"*Welding of Airplane Propeller Blades,*" by C. A. Liedholm, Curtiss-Wright Corp.

"*Welding of New Types of Alloy Steels in Aircraft Structures,*" by A. R. Lytle, Union Carbide and Carbon Res. Labs.

"*Effect of Current on the Welding of X4130 Aircraft Tubing,*" by W. T. Tiffin, University of Oklahoma.

TUESDAY AFTERNOON, OCT. 13

Session on Weldability of Steel

"*Bead Hardness and Bead Bend Tests on Carbon-Manganese Steels,*" by O. E. Harder and C. B. Voldrich, Battelle Memorial Institute.

"*Weldability of Carbon-Manganese Steels,*" by C. E. Jackson, Naval Research Lab.

"*Jominy and Quench Tests on Carbon-Manganese Steels,*" by G. A. Timmons, Climax Molybdenum Co.

"*T-Bend Tests of Carbon-Manganese Steels,*" by L. C. Bibber and J. Heuschkel, Carnegie-Illinois Steel Corp.

Session on Aircraft Welding (Sheet)

"*Spot Welding in Aircraft Structures,*" by E. S. Jenkins, Curtiss-Wright Corp.

"*Standards and Recommended Practices and Procedures for Spot Welding Aluminum Alloys,*" by G. S. Mikhalapov, Chairman, Aircraft Welding Standards Committee.

"*Arc Welding of Magnesium Alloys,*" by W. S. Loose and A. R. Orban, The Dow Chemical Co.

"*Welding in Aircraft,*" by Francis H. Stevenson, Vega Aircraft Corp.

Session on Gas Cutting

"*Gas Cutting in Steel Mills,*" by S. D. Baumer, Air Reduction Sales Co.

"*Improved Methods of Machine Flame Cutting,*" by H. E. Rockefeller, The Linde Air Products Co.

"*Factors Affecting the Accuracy of Machine Cutting,*" by Howard Hughey and A. H. Yock, Air Reduction Sales Co.

TUESDAY EVENING, OCT. 13

Fundamental Research Conference—H. C. Boardman, Chairman, Presiding.

WEDNESDAY MORNING, OCT. 14

Session on Resistance Welding

"*Refrigerant Cooled Spot Welding Electrodes,*" by F. R. Hensel, E. I. Larsen and E. F. Holt, P. R. Mallory & Co.

"*Spot Welding of Hardenable Steels,*" by W. F. Hess and D. C. Herrschaft, Rensselaer Polytechnic Institute.

"*Unusual Resistance Welding Developments and Operations,*" by R. T. Gillette, General Electric Co.

"*Resistance Welding Trench Mortar Fin Assembly,*" by J. H. Cooper, Taylor-Winfield Corp.

That which is past is gone and irrevocable, and wise men have enough to do with things present and to come.
BACON

SINCE PEARL HARBOR!

Superior might have done more
All Industry could have gone further
Every Government Agency set up to direct War Production hoped to do better
All U. S. Services—Army, Navy, Marines, Air Corps—expected more to be accomplished . . . *BY NOW*

★

But why cry about what might have been?

★

Let us follow Bacon's philosophy and be wise enough "*to do with things present and to come.*"

★

With eyes front and no looking back our objective is more easily reached. Let us act like men, be vigorous and do away with petty things.

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SUPERIOR TUBE CO., NORRISTOWN, PENNSYLVANIA

THE BIG NAME IN
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Tentative Technical Program of the

Wire Association

At the annual convention of the Wire Association, Oct. 12 to 15, nearly 12 technical papers, lectures and special addresses have been scheduled. The headquarters are at the Carter Hotel where all meetings are to be held. The technical papers embrace both ferrous and non-ferrous topics.

The Mordica Memorial Lecture this year will be delivered Wednesday morning, Oct. 14, by Louis H. Winkler, metallurgical engineer of the Bethlehem Steel Co., Bethlehem, Pa. His topic is "Steel and Wire."

The annual (stag) dinner is announced for Wednesday evening.

The tentative program of papers is as follows:

MONDAY AFTERNOON, OCT. 12

President's Address of Welcome (Short)

"Salvage," by War Production Board Speaker.

Motion Picture—*"Mines Above Ground—Conservation of Scrap and Waste Material."* Western Electric Co., New York.

"Rubber Insulation Substitutes"—Paper by Bell Telephone Laboratories.

TUESDAY MORNING, OCT. 13

"Wire Mill Safety Practices," by R. H. Ferguson, Mgr. of Safety Republic Steel Corp., Cleveland.

"Scheduling and Planning the Wire Mill for War Production," by L. D. Seymour, Asst. Wks. Mgr., Canada Works, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

TUESDAY AFTERNOON, OCT. 13

Wire Association Annual Luncheon

Guest Speakers: Hon. Everett M. Dirksen, Congressman of the Sixteenth District of Illinois and Dr. Charles Copeland Smith, National Association of Manufacturers, New York.

Wire Association Annual Meeting

WEDNESDAY MORNING, OCT. 14

"Tungsten Carbide Applications," by A. MacKenzie, Vice Pres. Chg. Mfg. Carboloy Co., Inc., Detroit.

Mordica Memorial Lecture

"Steel and Wire," by Louis H. Winkler, Met. Engr., Bethlehem Steel Co., Bethlehem, Pa.

WEDNESDAY AFTERNOON, OCT. 14

"Trouble Shooting on Bronze and Steel Weaving Wire," by L. D. Granger, Asst. to Vice Pres., Wickwire Spencer Steel Co., New York, N. Y.

"Welding Electrodes," by Dr. John W. Miller, Metallurgist, Reid-Avery Co., Dundalk, Baltimore Md.

WEDNESDAY EVENING, OCT. 14

Annual Smoker—Dinner (Stag)

THURSDAY MORNING, OCT. 15

"Pickling of Rod and Wire," by Walter G. See, Sales and Service Mgr., Submerged Combustion Co. of America, Hammond, Ind.

"Electric Patenting of Wire," by John P. Zur, Met. Engr., Trauwood Engineering Co., Cleveland.

AMERICAN WELDING SOCIETY

(Continued from page 686)

SESSION ON PRODUCTION WELDING

"Welding with Aluminum Bronze," by Clinton E. Swift, Ampco Metal, Inc.

"Adapting Automatic Electric Welding to Routine Production," by J. M. Keir, The Linde Air Products Co.

"Welded Steel Tubing and Its Application in War Production," by H. S. Card, Formed Steel Tube Institute.

WEDNESDAY AFTERNOON, OCT. 14

SESSION ON RESISTANCE WELDING

"The Spot Welding of NAX High Tensile Steel," by C. R. Schroder, Great Lakes Steel Corp.

"Application of Copper Oxides Rectifiers for Resistance Welding," by R. I. Briggs, Thomson Gibb Electric Welding Co.

"The Effect of Weld Spacing on the Strength of Spot-Welded Joints," by R. Della-Vedowa and M. M. Rockwell, Lockheed Aircraft Corp.

"Preparation of Aluminum Alloys for Production Spot Welding," by T. E. Piper, Northrop Aircraft, Inc.

SESSION ON WELDING OF ORDNANCE

"Conservation and Substitution of Critical Materials in Filler Metals," by A. N. Kugler, Air Reduction Sales Co.

"Manual and Automatic Welding of Heavy Plate of Hardenable Alloys," by L. A. Danse, Cadillac Motor Car Co.

"Developments in Cast Iron Welding Rods and Electrodes," by R. J. Franklin, Chicago Hardware Foundry Co.

"Electric Welding of Mobile Artillery Gun Carriages," by G. E. Campbell, Pettibone-Mulliken Corp.

SESSION ON SHIPBUILDING

"Suggested Methods Which Will Increase Welding Production and Decrease Welding Costs," by J. F. Lincoln, Lincoln Electric Co.

"Distortion and Shrinkage Problems in Ships and Other Large Structures," by Lomatte Grover, Air Reduction Co.

"Motor Boat Construction and Small Ships," by W. E. Whitehouse, Defoe Shipbuilding Co.

"Application of Welding in Submarines Construction," by E. H. Ewertz, Electric Boat Co. and R. D. West, Manitowoc Shipbuilding Co.

THURSDAY MORNING, OCT. 15

SESSION ON AIRCRAFT WELDING

"Utility Characteristics of Aircraft Electrodes," by C. B. Voldrich and R. D. Williams, Battelle Memorial Institute.

"Results of Survey on Current Arc Welding Practice in Aircraft Industry," by Maurice Nelles, Chairman, Western Aircraft Welding Committee.

"Copper Welding for Aircraft," by T. V. Buckwalter, Timken Roller Bearing Co.

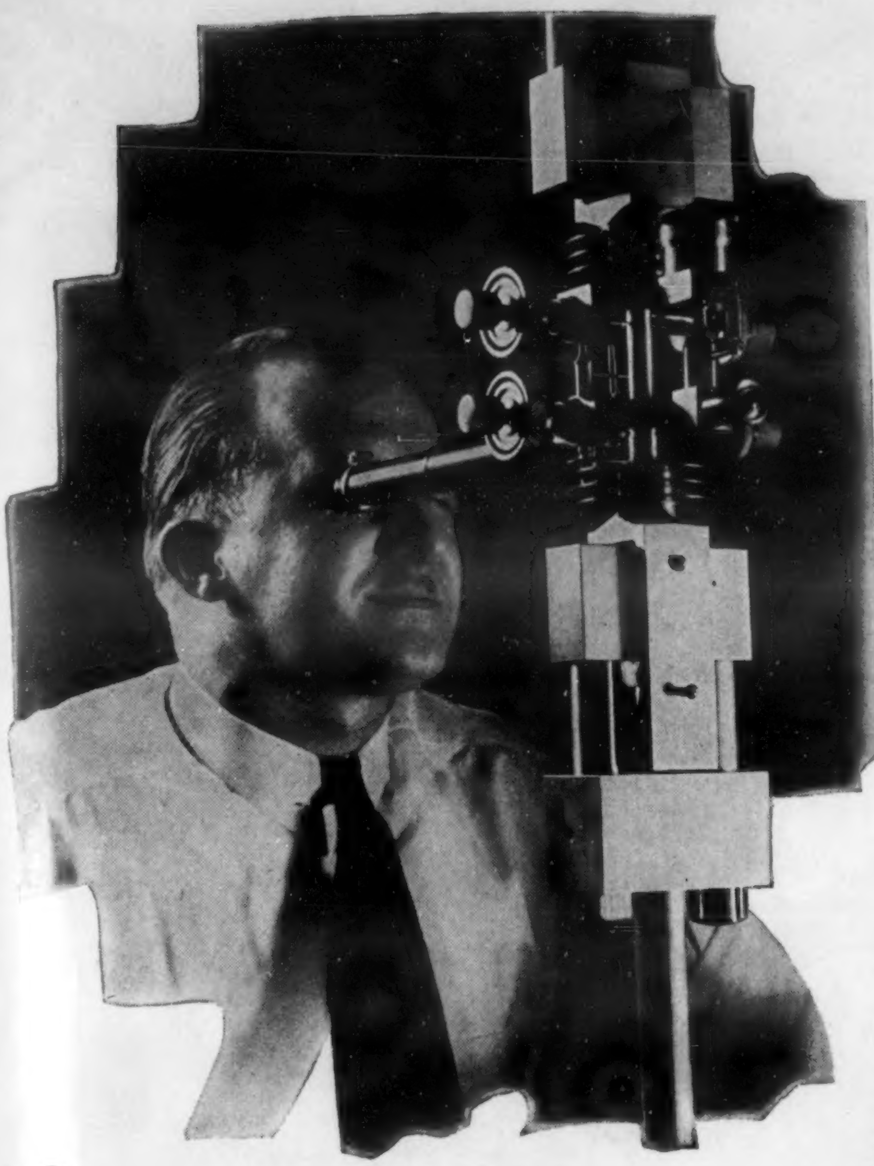
SESSION ON NON-DESTRUCTIVE TESTS AND INSPECTION

"Correlation of Metallographic and Radiographic Examinations of Spot Welds in Aluminum Alloys," by Dana W. Smith and Fred Keller, Aluminum Co. of America.

"The Magnetic Powder Method for Inspecting Weldments and Castings for Sub-Surface Defects," by Carleton Hastings, Watertown Arsenal.

"Radiographic Inspection of Welded Armor Plates and Castings," by Don M. McCutcheon, Ford Motor Co.

"Visual Inspection of Arc Welds," by W. L. Warner, Watertown Arsenal.



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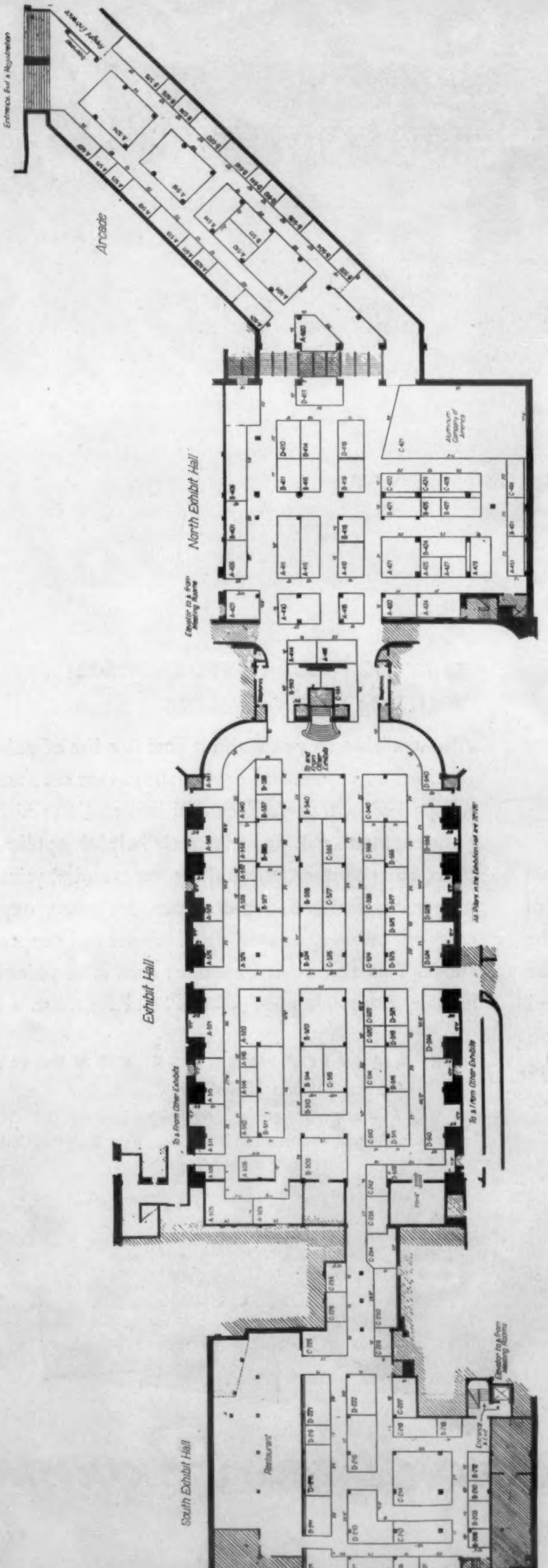

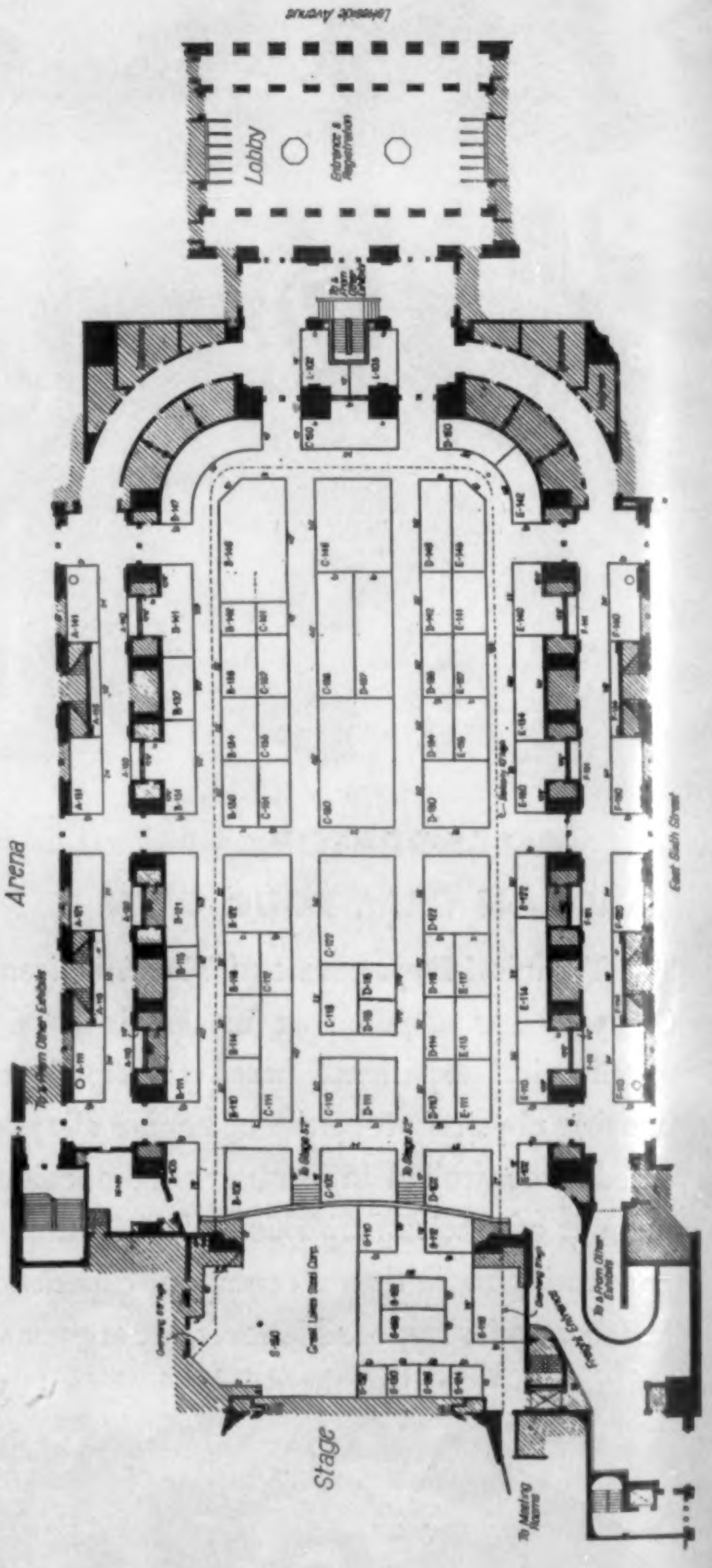

Floor Plan of the

National Metal Exposition

Cleveland, Oct. 12 to 16, 1942

List of EXHIBITORS

Acme Electric Welding Co., Huntington Park, Calif.—Booth A-500.
Advance Polishing Wheels, Inc., Chicago.—Booth E-113.
Agfa Ansco Div., General Aniline & Film Corp., Binghamton, N. Y.—Booth C-238.
Alloy Castings Co., Champaign, Ill.—Booth B-502.
Alox Corp., Niagara Falls.—Booth B-516.
Aluminum Co. of America, Pittsburgh.—Booth C-421.
Aluminum Ore Co.—Booth C-421. See Aluminum Co. of America.
Alvey Ferguson Co., Cincinnati.—Booth S-162.
American Brake Shoe & Fdry., New York City.—Booths A-525 and B-320.
American Brass Co., Waterbury, Conn.—Booth A-321.
American Car and Foundry Co., New York.—Booth B-314.
American Foundry Equipment Co., Mishawaka, Ind.—Booth D-340.
American Gas Furnace Co., Elizabeth, N. J.—Booth B-103.
American Institute of Mining and Metallurgical Engineers, Inc., New York.—Booth B-508.
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American Manganese Steel Div. of American Brake Shoe & Fdry. Co., Chicago Heights, Ill.—Booth A-525.
American Metal Market, New York.—Booth D-319.
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American Welding Society, New York.—Booth A-427.
Ampco Metal, Inc., Milwaukee, Wis.—Booth B-131.
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Andresen, Inc., Pittsburgh.—Booth B-210.
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Atlas Steels Ltd., Welland, Ont., Canada.—Booth D-113.
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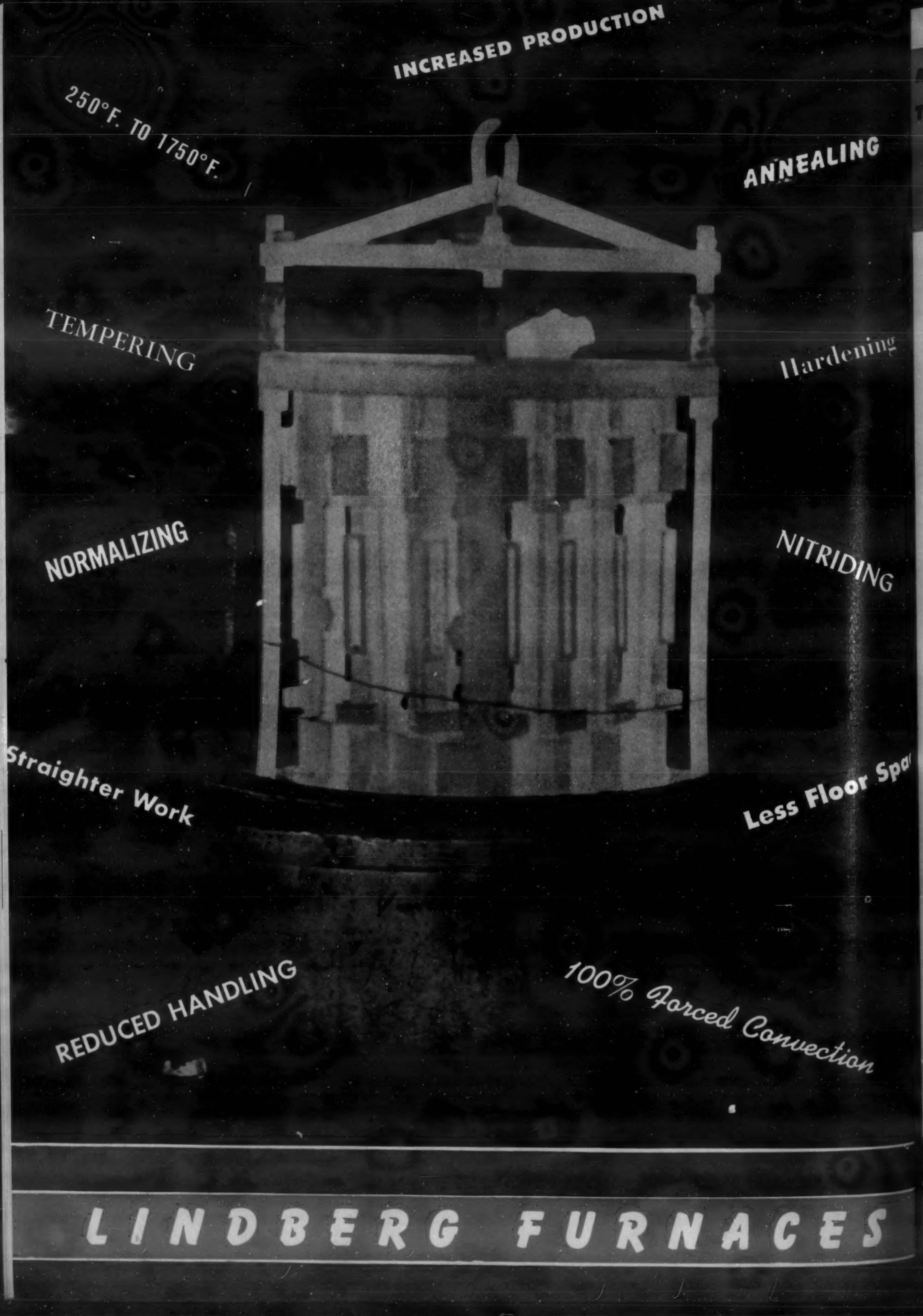
(Continued on page 702)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250°F. TO 1750°F.
ANNEALING
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Straighter Work
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ALL THE ADVANTAGES OF 100% FORCED CONVECTION HEATING IN THE HARDENING, NORMALIZING AND ANNEALING RANGE WITH THE

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The first furnace of its kind, employing 100% forced convection heating with a temperature range from 250° F. to 1750° F., the Lindberg developed Super-Cyclone is an ideal furnace for hardening, normalizing, annealing, tempering or nitriding. As a result of the 100% forced convection heating principle, production is increased, distortion minimized, material handling is reduced and less floor space is required to handle the same or increased production over conventional equipment.

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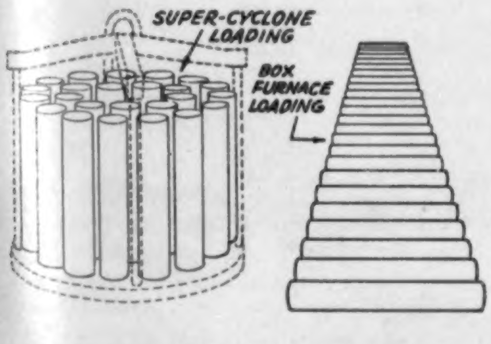
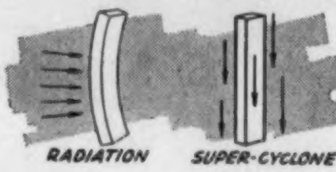
"Worm gear hardening *3 times greater* . . . bearing race hardening *7 times greater* . . . gray iron casting annealing *12 times greater.*" You can figure



the Super-Cyclone's production possibilities in your own shop by spreading an average load of parts on the floor, one layer thick, as handled in a radiation type box furnace. Measure the area required. Take another load of the same parts and stack them up in a 36" circle, 4' high, making allowance for spacers and supports. Figure it will take a maximum of 3 hours to heat the load and 5 minutes to quench the lot. Ordinarily you will find, by comparison with the laid out parts, that the Super-Cyclone will handle larger loads in the same or less time with a consequent increase in production, in some cases as high as 1200%.

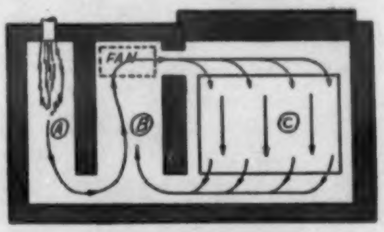
KEEPS WORK STRAIGHTER

"Worm gear straightening was reduced from 85 out of 100 to 10 out of 100, thus saving 7½ hours straightening time per 100 worm gears." Rings that were previously heated and quenched



individually on special jigs to hold them round, are now heated in a Super-Cyclone and quenched, 63 at a time without jigs, and held well within the acceptable range of .010".

The 100% forced convection heating principle of the Super-Cyclone heats the work rapidly and uniformly by driving heated air through the charge at high velocity. The heat source is confined to a separate chamber (A) away from the work (C) and separated by the fan chamber (B), thus



preventing radiant heat of a source hotter than the desired work temperature from striking the charge and causing distortion. As a result, valuable man hours are saved from the straightening press and made available for other work.

REDUCED HANDLING

The use of a fixture in the Super-Cyclone eliminates the individual handling of pieces throughout the heat treating process. The parts are loaded onto the fixture and remain there during the heating, quenching and tempering stages, and too, in reducing distortion to a minimum, the Super-Cyclone eliminates extra handling of work for straightening.

LESS FLOOR SPACE

Based on averages of what the Super-Cyclone has done in other plants, you can figure that it will require not more than ⅓rd the floor area demanded by conventional equipment to handle the same or greatly increased production. In one plant alone, *a Super-Cyclone replaced 8 box type furnaces and turned out twice as much work!*

The Super-Cyclone's efficiency of operation, savings in man hours through the reduction of handling time and distortion, and economy of floor space, makes it an ideal production unit for the large or small shop.

The Super-Cyclone is made in a wide range of sizes from 16" diameter by 20" deep to 72" diameter by 84" deep. Most are gas fired although a number are available electrically heated.

> Write today for Bulletin 130 or ask to have the Super-Cyclone explained to you at the Lindberg Booth, National Metals Congress, Cleveland, October 12 through 16.

LINDBERG ENGINEERING COMPANY

2451 WEST HUBBARD STREET • CHICAGO

CYCLONE FOR LOW-COST ACCURATE TEMPERING

SUPER-CYCLONE FOR HARDENING, ANNEALING, NORMALIZING, TEMPERING, NITRIDING

HYDRYZING FOR SCALE-FREE AND DECARB-FREE HARDENING

(Continued from page 699)

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METALLURGICAL ENGINEERING shop notes

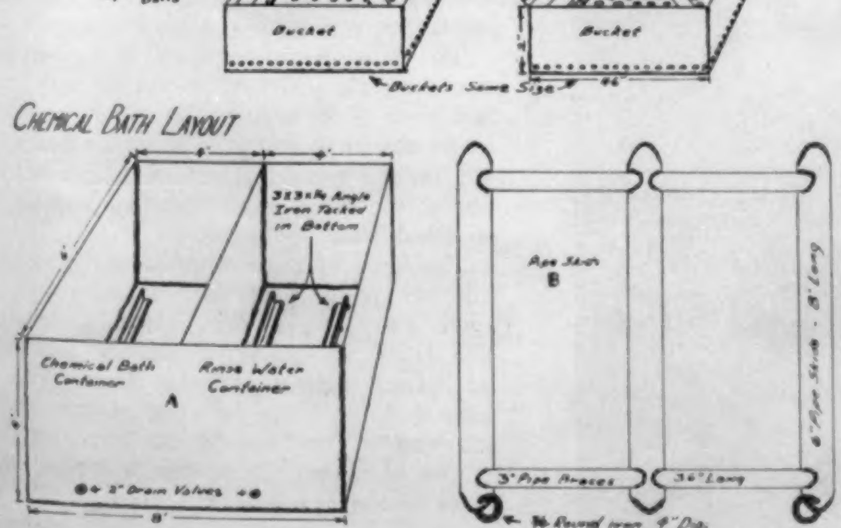
Cleans Pipe—Made from Scrap

by W. R. Tierce,
Illinois Pipe Line Co.

By using the metal from a scrap pile and his arc welder to construct it into a useful tank, the author, welding operator for the Illinois Pipe Line Co., saved 128 man hours with his fast, new methods for cleaning pipe line connections.

The usual method is to clean them with a wire brush with either gasoline or kerosene. Now maintenance men use a chemical bath, which cuts down cleaning time tremendously. The connections are placed in the dipping buckets (shown in the drawing) and placed in the chemical bath section of the cleaning tank. ("A"—in drawing.) A fire is lighted under the tank and the connections left to boil for five hours.

Next, the fire is put out and the bucket withdrawn from the bath, given time to drain, and plunged five or six times into the rinse section of the tank. When cool, a few passes with a wire brush will clean connections perfectly. Then the connections are painted and placed in stock for further use.



All metal for the dip tank and dipping buckets was taken from the company's scrap pile. The tank was constructed by welding sections of an old 1/8 in. flat sheet tank bottom. Bucket guides and rests on the bottom of the tank were made from 3 in. x 3 in. angle iron. A 2-in. drain valve drains each compartment. Tank skids were made from 6-in. and 3-in. pipe, as shown in the drawing.

The dipping buckets were constructed also by welding 1/8 in. sheet tank bottoms. Bails were made from 3/4 in. round iron scrap; hinge straps from 3/8 in. x 2 in. x 8 in. iron. Holes were drilled into the bucket bottom for draining. Each bucket holds one ton of connections.

The bucket and dip tank cost only $46.22 to construct, including materials, labor and overhead. For comparison, the company cleaned the same amount of connections by both methods. Cleaning by wire brush and kerosene took four men six days time, or 192 hours. Cleaning with the welded chemical dip tank took four men two days, or 64 hours. A single application of the new cleaning process paid for its construction.

The accompanying illustration is through the courtesy of Hobart Bros. Co., Troy, Ohio.

Ferric sulfate does an exceptionally good job of removing black smut and red cuprous oxide scale from the surface of brass, stain and scale formed by the annealing operation. It removes stains more quickly and with less loss of metal than previous chemicals used. It is being adapted to brass cartridge case manufacture.

—Merrimac, Div.,
Monsanto Chemical Co.

(More Shop Notes on Page 708)

Wanted: Tools to Cut Rough, Not Smooth

by Fred W. Lucht,
Carboloy Co., Inc.

In mythical "Never-Never Land" right is wrong and wrong is right. Which is by way of introducing a new technique whereby a carbide tool was ground the

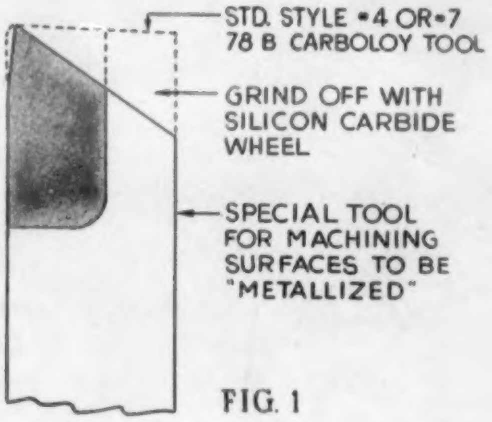


FIG. 1

"wrong" way to make a rough surface instead of the usual smooth. Hence, "wrong" in this case proved right.

The job was to roughen a surface preliminary to metal spraying so that a strong mechanical bond would result. Many types of metal do not form a chemical bond. Hence, for the roughing specially knurled tools, dove-tail shaped tools had originally been devised. Though the cost was high, these did a good job when the base material was easy to machine. But for many alloy steels the job was a little too tough.

Carboloy engineers took a standard carbide tool out of stock and ground the nose to the unorthodox shape in Fig. 1. What happened in machining tough alloy steel is seen in the accompanying photograph. Cuts are at different depths—0.010, 0.015 and 0.020 in.—and the feed is 0.030 in.

The tool raised a burr between tool marks, and this burr was pushed over into

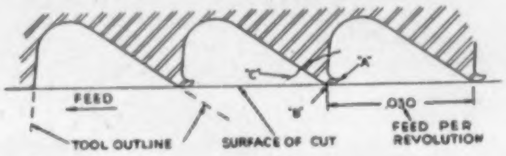
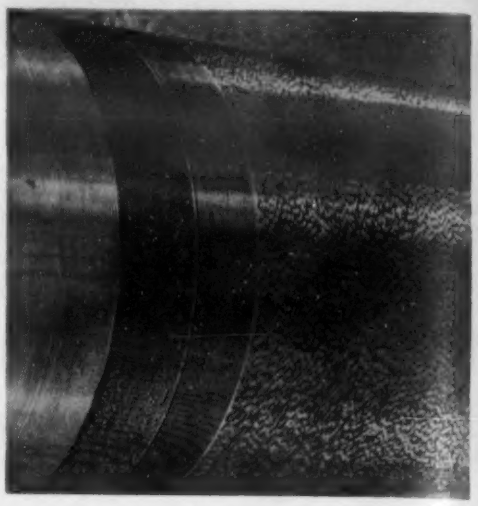


FIG 3

horizontal position. Both the photo and Fig. 3 show that the tool lifts some of the crests intermittently, thereby producing a mottled surface forming an ideal



base for the adhesion of sprayed metal. Cutting speed on this tough material was around 200 to 250 surface ft. per min.

Flame-Priming Steel for Painting

E. W. Deck
Linde Air Products Co.

Preparing large steel surfaces for painting by a blowpipe with a special head for the oxyacetylene flames is a relatively new process, used, for instance, on the Boulder Dam and the drum gates of Grand Coulee Dam. The special head provides closely-spaced rows of oxyacetylene flames, which, when applied to the surface to be treated, cause adhering rust and scale to pop off, leaving the metal underneath relatively unaffected, and warm and dry for the prime paint coat.

The process is applicable to all types of structural steel work, storage tanks, dams, locks, piling, railroad cars, ships, steel work on subways, airplane hangars and pipe lines. It offers several advantages over wire-brushing, pickling and sand-blasting.

It increases cleaning and painting rates and reduces setting time for the paint. Painting can be done in low temperature or dampness that would otherwise cause major delays. It drives moisture off the surface. Heat on surface to be painted thins the paint and lowers its surface tension. It imparts a wetting action, causing the vehicle and pigment to

penetrate into cracks, crevices and pitted sections and carrying the inhibitors into contact with the base metal, resulting in a mechanical bond as well as an adhesive one.

On the warm surface brushing is easier, with a smoother finish having fewer voids. The paint sets up more quickly—from the metal out, eliminating skins and blisters.

The heating action must be rapid, or else the scale will become ductile and soft and fuse to the base metal rather than spall off under stress. What oxides are left on the metal surface are stable, help protect the metal from corrosion and form an ideal base for paint.

The heart of the equipment is the head. The 49 flame ports are spaced ⅛ in. apart and give a 6-in. flame coverage. The ports are No. 75 drill size or 0.02 in. diam. Flames are over ¼ in. long, with 1 to 1 ratio between oxygen and acetylene. The head is attached directly to the blowpipe, or to the blowpipe by an extension arm.

—Bakelite Review

Quick, easy tests for qualitative identification of some common white metals and alloys

The following procedures will distinguish among Monel, "S" Monel*, "K" Monel*, Nickel, 30 per cent copper nickel, nickel silver, Inconel*, chromium-iron and chromium-nickel stainless steels, Ni-Resist*, ordinary steel, and cast iron. Before testing, the material should be cleaned with emery cloth or a file to remove dirt, grease or corrosion products, or any metallic coating such as galvanizing.*

Test with a Strong Horseshoe Magnet

1. If the material is strongly magnetic, it may be nickel, ordinary steel, cast iron or chromium-iron stainless steel. Confirm as in Procedure A.

2. If the material is slightly magnetic, it probably is Monel† or cold-worked 18-8 stainless steel with or without molybdenum. Confirm as in Procedure B or heat the specimen in hot water, preferably boiling, and retest with a magnet while hot. If the specimen loses its magnetism when heated it is MONEL.

3. If the material is non-magnetic, it may be copper nickel, nickel silver, "K" Monel, "S" Monel, Inconel, chromium-nickel stainless steel with or without molybdenum, or Ni-Resist. Confirm as in Procedure C.

Procedure A

FOR STRONGLY MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts slowly to a pale-green color, the material is NICKEL.

2. If the acid reacts slowly to a brown-black color, the material is either ORDINARY STEEL, LOW-ALLOY STEEL or CAST IRON.

3. If no reaction occurs, the material is CHROMIUM-IRON STAINLESS STEEL.

Procedure B

FOR SLIGHTLY MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts to a green-blue color, MONEL is indicated.

2. After reaction has ceased, add one or two drops of water, immerse an iron nail or steel knife blade in the drop and in contact with the test sample. If the nail or knife blade becomes coated with copper, or if a copper deposit appears on the material being tested, the latter is MONEL.

3. If no reaction occurs, the material is heavily cold-worked CHROMIUM-NICKEL STAINLESS STEEL.

Procedure C

FOR NON-MAGNETIC MATERIALS

Place a drop of concentrated nitric acid on a cleaned area.

1. If the acid reacts rapidly to a blue-green color, the material is NICKEL SILVER or COPPER NICKEL.

2. If the acid reacts to a green-blue color, the material is "K" MONEL or "S" MONEL. The form of the material will usually assist in identification since "K" Monel is never cast and "S" Monel is never wrought.

3. If the acid reacts to a brown-black color, the material is NI-RESIST.

4. If no reaction occurs, the material may be either Inconel or chromium-nickel stainless steel with or without molybdenum.

To distinguish between Inconel and the stainless steels:

(a) Place on the sample a few drops of a solution containing 10 gm. of cupric chloride ($CuCl_2-2H_2O$) in 100 cc. of concentrated hydrochloric acid and allow it to stand for 2 minutes. Then slowly add a few drops of water, one drop at a time, and finally wash off the solution. If a copper-colored spot remains, the material is CHROMIUM-NICKEL STAINLESS STEEL with or without molybdenum; if an uncolored etched spot remains, the material is INCONEL. Or

(b) Place 1 drop of concentrated hydrochloric acid on a clean surface of the alloy and allow it to react for 1 minute. Then add 1 drop of an acid ferricyanide solution containing 1 per cent by weight of potassium ferricyanide, $K_3Fe(CN)_6$, and 10 per cent by weight of sulfuric acid. If a dark blue color appears quickly, the material is CHROMIUM-NICKEL STAINLESS STEEL with or without molybdenum; if no color develops it is INCONEL.

(c) A distinction may be made between the types 316 and 317 stainless steel, which contain molybdenum, and the chromium-nickel types 302 and 304. The test is made by immersing the alloy in an aqueous solution containing 75 per cent by weight of orthophosphoric acid (H_3PO_4) and 1 to 30 gm. per liter of sodium chloride (common salt) at 140° to 200° F. If the stainless steel does not contain molybdenum (Types 302 or 304) bubbles of hydrogen will begin to form within 30 sec. If the alloy contains molybdenum (Types 316 and 317) bubbles will not form. The quantity of sodium chloride and the testing temperature are not critical within the limits indicated.

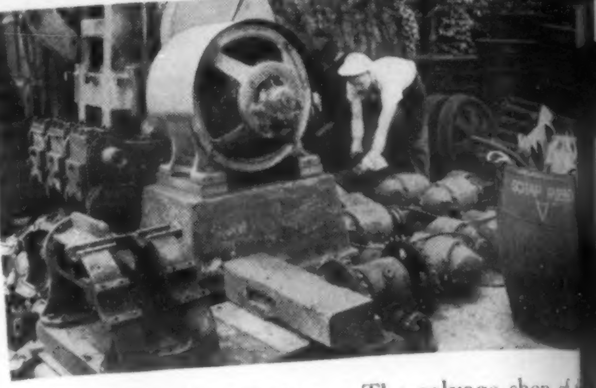
*REG. U. S. PAT. OFF.

†This test should be made preferably after cooling the metal with ice water or a freezing mixture, which will increase the magnetic strength and permit easier distinction between Monel and nickel-copper alloys of lower nickel content, e.g., nickel silver.

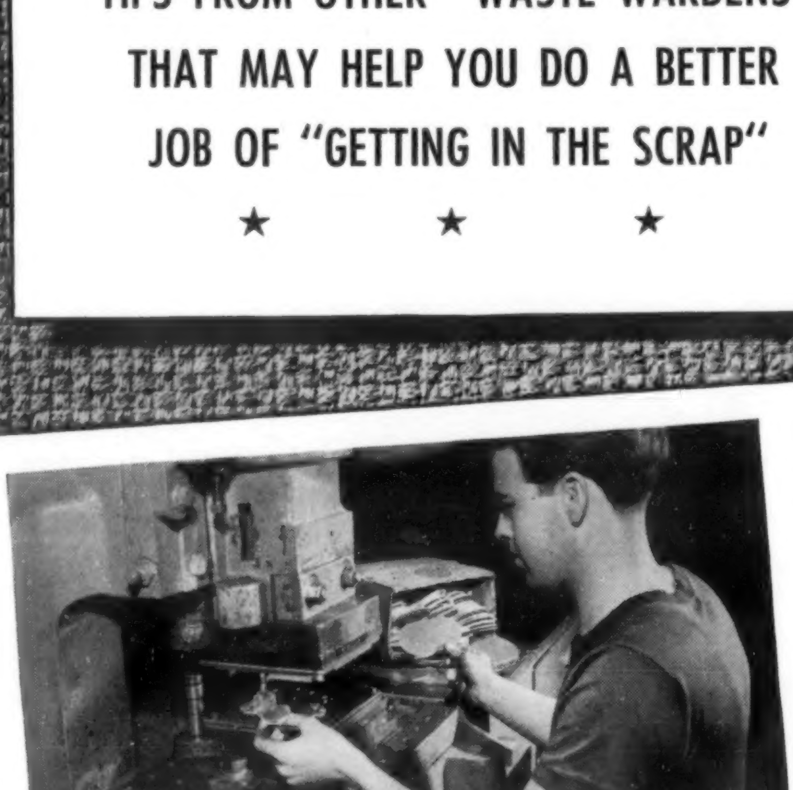
NEWS from the scrap front

TIPS FROM OTHER "WASTE WARDENS" THAT MAY HELP YOU DO A BETTER JOB OF "GETTING IN THE SCRAP"

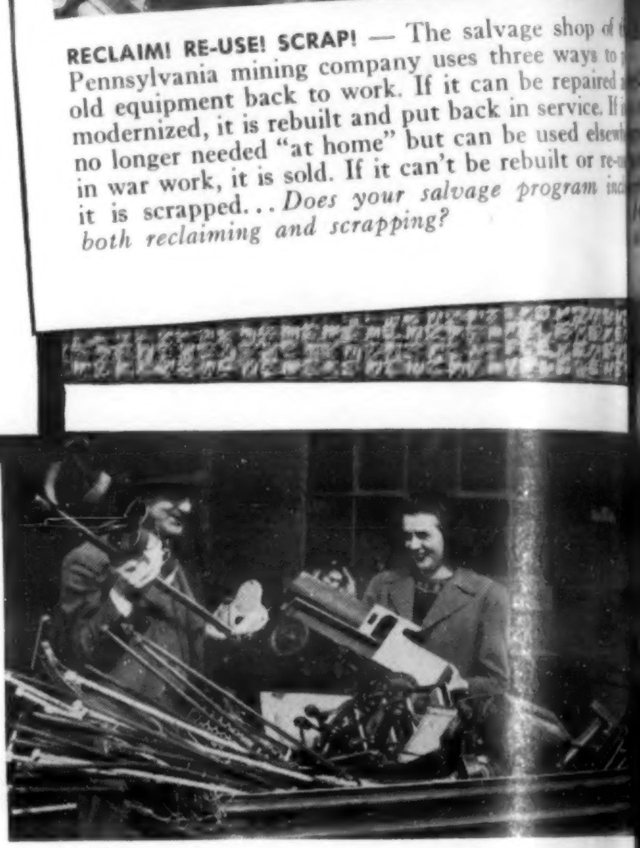
★ ★ ★



RECLAIM! RE-USE! SCRAP! — The salvage shop of t Pennsylvania mining company uses three ways to old equipment back to work. If it can be repaired modernized, it is rebuilt and put back in service. If no longer needed "at home" but can be used elsewh in war work, it is sold. If it can't be rebuilt or re- it is scrapped... *Does your salvage program inc both reclaiming and scrapping?*



SOME SCRAP ISN'T SCRAP! — One airplane builder has found that metal pieces left over from making larger parts can be used to make smaller parts. The worker shown is stamping small parts from metal cutouts resulting from making larger stampings. Waste is reduced, too, by altering template blank sizes, changing drop hammer and punch press dies, and improving layout . . . *Are you using every means to get maximum production out of the metal supplied to your company?*



EMPLOYEES BECOME "SCRAP SNOOPERS" — In addition its year-round salvage program, a New England war pl recently enlisted its employees in an "all-out" scrap roun up. Workers searched their homes, offices, work-bench tool chests and shop floors. Over 350,000 extra pounds metal scrap was collected... *Are you making all your em ployees "scrap conscious"? Have you tried an incentive sy tem to stimulate scrap collection?*

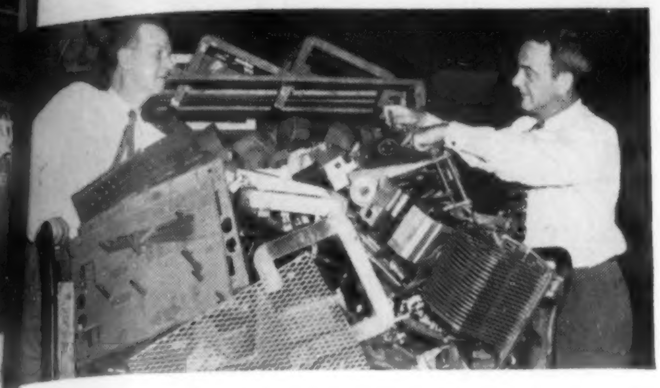
THE SCRAP IS COMING IN...*but not fast enough!*

We have the proof that industry is cooperating in the drive for scrap metals... proof measured in thousands of tons. But mills must get *more* iron and steel scrap if they are to meet the gigantic needs of war industry.

Don't forget... steel gets to work on the battlefront more quickly when plenty of scrap is available. Scrap is already metallic. Therefore, less ore needs to be converted into pig iron per ton of steel produced. By remelting scrap to make new steel, more tons of high-quality products can be turned out in a hurry for war purposes.

So make it your personal war assignment to see that your organization does a thorough, continuous job of "getting in the scrap." Cooperate closely with your local Industrial Salvage Committee. This is one drive that must not fail!

UNITED STATES



NO HOARDING HERE — A midwest novelty manufacturer (now engaged in war work) recently turned in over two million pounds of metal parts, tools and machinery at scrap prices. . . . *Are you holding idle stocks of obsolete and useless metal parts and equipment for some uncertain future need? In most cases they're worth more to your country as scrap than they'll ever be to you.*

"PAINLESS EXTRACTION" OF CAR RAILS — This new rail remover can pull up 4000 lineal feet of rail a day, its designers say. Besides speeding the salvage job, it reduces damage to pavements and simplifies repaving. 60,000 tons of rail in New Jersey soon will be removed with this type of machine. . . *Is your community taking full advantage of modern salvage equipment to recover unused car rails for scrap?*

SEGREGATION MINIMIZES SCRAP LOSS — A western aircraft plant has more than doubled its scrap collections by applying a centrally-directed salvage system. All metal scrap is segregated into solids and machinings, and also by alloy content, right at the machines. Scrap containers are color-banded and labeled to identify clearly what goes into each. . . *Has your company set up an efficient scrap collection system? Is scrap carefully segregated?*

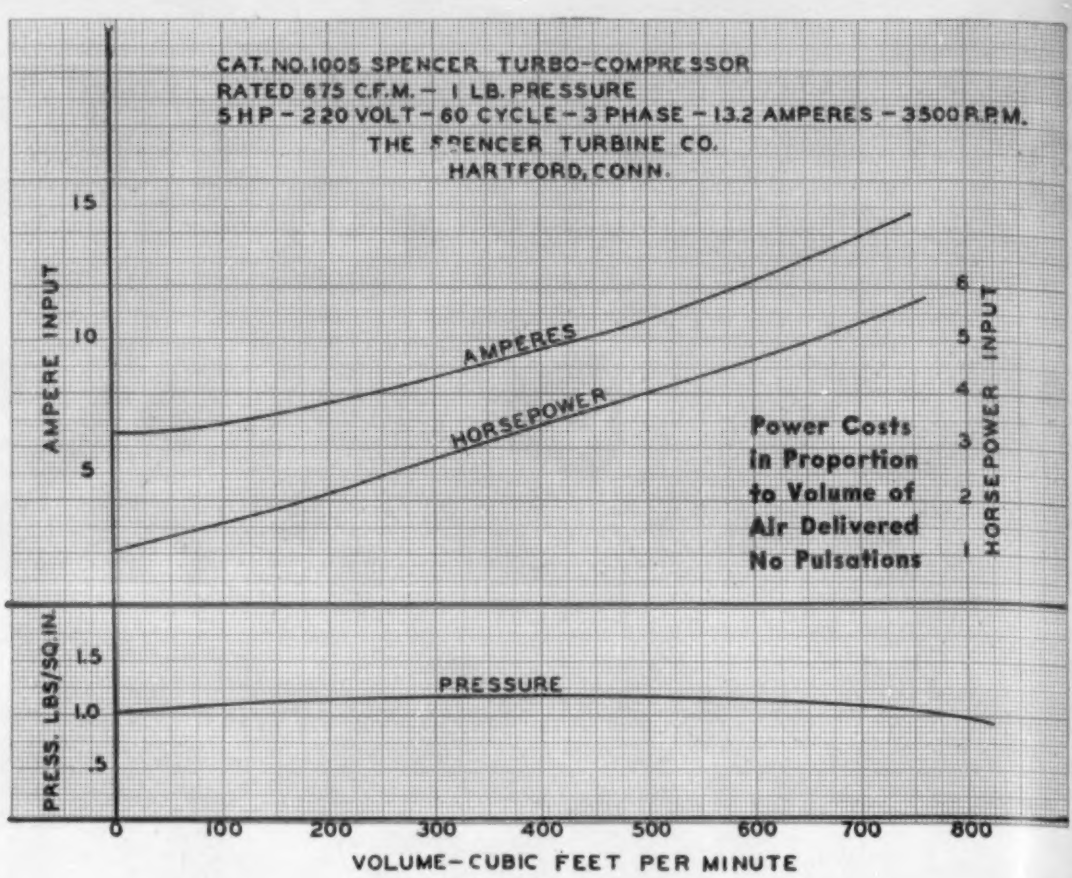
WE "PRACTICE WHAT WE PREACH" — In one of many large-scale salvage operations, a United States Steel subsidiary recently dismantled for scrap several of its own mill buildings which were no longer suited to present practices. The yield was 3500 tons of scrap . . . *Do you have any steel structures, idle now and of doubtful future value, which should be wrecked to release scrap?*

SEGREGATION
is increasingly important!

Wherever possible, sell your scrap in lots that have been carefully segregated, classified and labeled according to their type and metallic make-up. By making it easy for steel mills to identify accurately the alloy content of your machinings and other scrap, you help to speed production of NE Steels and make possible full utilization of valuable alloys your scrap contains. Segregated scrap will bring you a better price, too.

AMERICAN STEEL & WIRE COMPANY, *Cleveland, Chicago and New York* · CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago* · COLUMBIA STEEL COMPANY, *San Francisco* · NATIONAL TUBE COMPANY, *Pittsburgh* · TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

Low Power Costs



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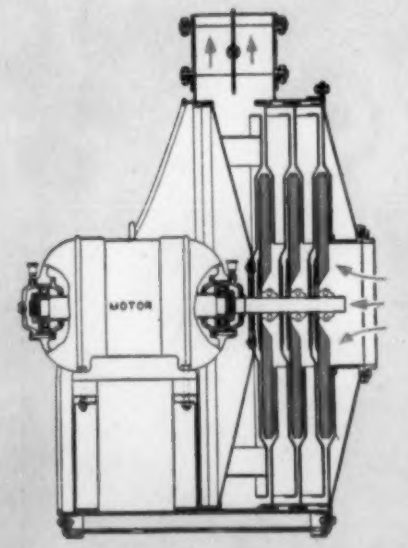

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S-231D

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

1. Production

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die-Castings.

2. Processing and Fabrication

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3. Design and Applications

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4. Testing and Control

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings. Surface Measurements. Metallographic Structure and Constitution.

1 Production

OF METALS, MILL PRODUCTS, CASTINGS

Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining • Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment • Melting and Manufacture of Non-Ferrous Metals and Alloys • Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces • Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice • Foundry Practice, Furnaces, Equipment and Materials

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Efficient Crucible Melting

Condensed from "Transactions American Foundrymen's Association"

The experimental furnace designs described here were an effort to build a furnace that would have high fuel efficiency, fast melting, a minimum of contact between products of combustion and the molten metal, low metal loss and better working conditions at the furnace.

There are tilting crucible furnaces known as the sealed-in type where there is no contact with the flame and, therefore, low metal loss, but they do not have as high a fuel efficiency or melting speed as the more conventional type where the flame passes over the top of the crucible.

The first problem was to get more heat into the metal without passing the combustion products over the top of the crucible. As the fuel in-put was at its practical in-put limit, further increase was not considered. Pre-heating the air produced the desired result, but proper equipment had not been developed.

It was found that heating the outside of the furnace wall, to a temperature above 2000 deg. F., prevented loss of heat. This was done by removing the original steel shell, leaving a suitable space outside the original insulation for flue travel and then constructing a second wall of insulating refractory. The original shell then was replaced by one of greater diameter. Instead of exhausting the flame from the crucible chamber through one or two large ports, a number of smaller ones were used to give better distribution of heat.

For purposes of comparison, a furnace designed to take a No. 80 crucible was operated (1) as a conventional stationary or tilting furnace with flame passing over top of crucible; (2) as a recirculating sealed-in furnace. Results showed a small difference in heating-up time between the conventional design and the sealed-in recirculating design. The latter is somewhat superior above 2200 deg. F., where the advantage is the most useful. The recirculating open-top or non-sealed furnace showed a marked advantage because of higher furnace temperature, due to recirculation, plus the advantage of passing the flame over the top of the crucible.

During the experiment it was found that red brass borings melted in the sealed-top furnace without a flux showed a metal loss of 3.8 per cent, while those melted with a flux composed of 50 per cent borax and 50 per cent old glass showed 2.5 per cent loss.

If the dross obtained by melting without a flux is remelted with this flux, a major part of the metal can be recovered. Red brass ingot melted with this flux showed a loss of 0.53 per cent. If sufficient flux is used to produce an unbroken seal over the metal, this low metal loss can be obtained from all three types of furnaces.

Five consecutive heats of 200 lbs. each of red brass borings were run in each furnace, starting cold, and using ½ lb. flux per 100 lbs. of metal. The gas in-put was held constant at 300 cu. ft. per hr. of 1,000 B.t.u. gas. The CO_2 content was maintained at 11.6 per cent. The metal was brought to 2200 deg. F. and immediately poured.


1861
1898
191
1941

The conventional furnace and the sealed-in type showed little difference in melting speed and fuel consumption, the latter showing an average of 109 lbs. melted per hr., as against 108 lbs. in the former, and an average use of 2.63 cu. ft. gas per lb. as against 2.65.

The recirculating open-top showed an advantage with an average of 115 lbs. per hr. and an average gas consumption of 2.47 cu. ft. per lb.

The work had to be terminated before tests at increasing gas in-put could be made and the furnace was not run long enough to prove its practicability. The recirculating sealed-in furnace can be operated with greater comfort to the operator than the others.

Discussion after the reading of this paper brought out the facts that the furnace is 8 or 10 in. larger in diameter than the ordinary furnace, and that the high temperature of the down-take exhaust did not cause the insulating refractories to deteriorate. Also, that the plan was to build a furnace entirely of an insulating refractory and that a company has one out now that they claim will stand higher temperatures than silicon.

—G. K. Eggleston, *Trans. Am. Foundrymen's Assoc.*, Vol. 49, June 1942, pp. 1053-1074.

Centrifugally Cast Guns

Condensed from "American Machinist"

Anti-aircraft and other guns from about 1 up to 6 in. can be cast centrifugally to produce a single tube known as a monobloc gun. Coreless induction, high-frequency furnaces are used which hold just enough steel for the particular gun to be cast. Each centrifugal casting machine consists of a steel tube, mounted horizontally on bearings and provided with a motor by which it is rotated. Into it is placed a steel liner bored to the exterior dimensions of the gun to be cast. The mold is rotated at high speed during the pouring.

Shortly after pouring, the mold cover is removed and a hydraulic ram pushes out the red hot casting which is removed to a cinder bed for slow cooling. The gun is subsequently normalized, quenched (differential quench in water), and tempered before machining. After boring and rough machining, the gun tube is cold worked by subjecting to hydraulic pressure until the diameter of the bore is materially increased and the elastic limit of the steel almost doubled.

This treatment gives the same effect as is obtained in the built up gun by shrinking the jacket and hoops onto the tube, namely the layers of steel nearest the bore are put into a permanent state of compression which gives close to 100 per cent increase in gun powder charges and a substantial increase in range without increasing the wall thickness.

Centrifugal casting turns out several gun tubes in the time it takes to forge one with much less costly equipment and with the necessity for much less machining. The saving in time, labor, and material over a built up gun is from 25 to 40 per cent.

—C. T. Harris, Jr., *Am. Machinist*, Vol. 86, Aug. 6, 1942, pp. 822-823.

Precision Castings

Condensed from "The Iron Age"

Production of ferrous and non-ferrous castings to unusually close tolerances is being done by a method combining the so-called lost-wax process and centrifugal casting. Tolerances are 0.001 in. on all surfaces. A few small pieces are held to tolerances of 0.0005 in.

The master pattern is usually developed from a stock sample of the part. The sample is reproduced in bismuth alloy master pattern or in rubber or plastic mold, depending on the design or number of pieces to be made. The master mold is used to form a wax core or pattern.

On production runs, a pattern will carry several castings, exact number depending on the size of the piece. After the wax solidifies in the master pattern, the wax form is placed on a flat metal base. A cylindrical flask is placed over this and liquid investment poured into the flask. The air from the flask is removed by vibration or vacuum. Cold setting time is about 8 to 10 mins. The mold is slowly baked in an oven for about 2½ hrs. At the proper temperature the mold becomes liquid and is poured out.

The flask is ready for pouring. This is done in a centrifugal casting machine while the flask is hot. After the casting temperature drops past the critical zone, the flask is removed. The cooling period is 15 to 30 mins.

Sand blasting is used for final cleaning. The refractory material is very fine (will pass through 340 mesh when dry). The work is done in a range of 2800 to 3200 deg. F. Diameter of gates averages about 1/12 the greatest thickness of the casting. Molding is done in a 3 by 3 in. flask. Daily output from a mold averages 200 to 300 pieces. Maximum size of casting at present is limited to 2¼ by 2½ in.

—W. A. Phair, *Iron Age*, Vol. 150, July 9, 1942, pp. 39-41.

Cast Steel Mortar Shells

Condensed from "The Iron Age"

The steel being used at present has a minimum yield strength of 35,000 lbs. per sq. in., with an elongation of 30 per cent in 2 in. and reduction area of 50 per cent. After machining, the 60-mm. shell must have a volume capacity 8.7 cu. in. and variation not greater than 0.1 cu. in.

An electric, carbon-arc, tilting-type furnace from 4,000 to 22,000 lbs. capacity is used. The melting charge requires little more than 1 hr. and is divided into a high-voltage period of 195 volts; after ½ hr. it is reduced to 140 volts and at the end of that period to about 124 volts.

The accumulated first slag is raked off and a second slag of sand and lime is added as a protecting cover. The melt is then brought up to final specification by adding ferromanganese and silicon of an exact analysis.

Pouring is done at 2950-3000 deg. F. Shells are cast in 3-part mold consisting of cope, cheek and drag, with steel and brass patterns for each. Sixteen shells are cast to a mold.

Wartime needs demand time-saving wherever possible in acid-proof construction. Wartime pressure for the utmost in production means that corrosion-resistant construction *must* stand up. Penchlor Acid-Proof Cement meets both these requirements with a record of proved performance.

With Penchlor Acid-Proof Cement you can get brick-lined equipment into service without delay because this tough, long-lasting sodium silicate cement offers these advantages: Quick-setting and self-hardening—easily handled—no heating required—no drying delays—no acid treatment.

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Cores for the inside of the shell are set in the drag with the pouring-gate core in the center. The cope serves only to house the feeders. Metal is poured into the sprue and flows into the gates which are connected to 4 feeders. Pouring is done directly from big bottom-pour ladles.

Cores are made from new sand mill, core oil or dry binder and cereal. The baking time is ½ hr. at 450 deg. F.

A "triple heat treatment" is given the shells in radiant-tube-type furnace with a series of gas-fired, hairpin shaped tubes located above and below the hearth. The purpose of heat treatment is to break up the as-cast crystalline grain structure and produce one with maximum amount of ferrite so as to give the ductility specified.

Shells are then tumbled, shot-blasted inside and nose-pressed in a hydraulic press, so that machining chuck can have a smooth surface to grip.

—J. B. Nealey, *The Iron Age*, Vol. 150, Aug. 13, 1942, pp. 47-52.

Iron and the Open-Hearth

Condensed from "Steel"

Pig iron and scrap have always been major constituents of the open-hearth charge. Variation in the amounts of iron have a profound effect upon the entire steel-making practice. During the past year or so, steelmakers have been forced to increase their iron charge in the open-hearth because of the current scrap shortage. The intention here is to point out to some extent how this change of practice affects the industry.

[The authors here discuss scrap exports, scrap collection and circulating scrap revealing a gradually accumulating shortage.]

It can readily be appreciated that a scrap shortage produces a major production crisis, with a war going on. With a diminishing circulating scrap market and an economic end point of collectable scrap not too far out of sight, it becomes apparent that something be done immediately.

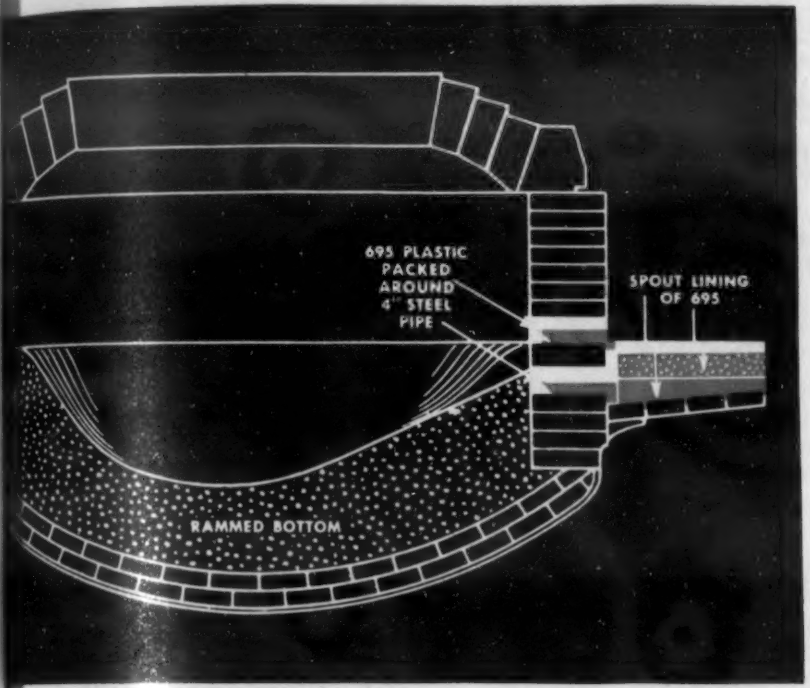
Building more blast furnaces is no simple answer to the problem. Plates, structural and fabricated shapes, castings and forgings must be made from the present steel supply for the construction of these [23 new] stacks. Stoves, cast houses, hoists, ladles, boilers, turbo blowers, numerous motors and quantities of piping and wiring must also be supplied. Nor does the list end with the furnace alone.

Increased open-hearth tonnage, additional hot and cold mill capacity and finally the finishing capacity for war production contribute to the ramifications of the

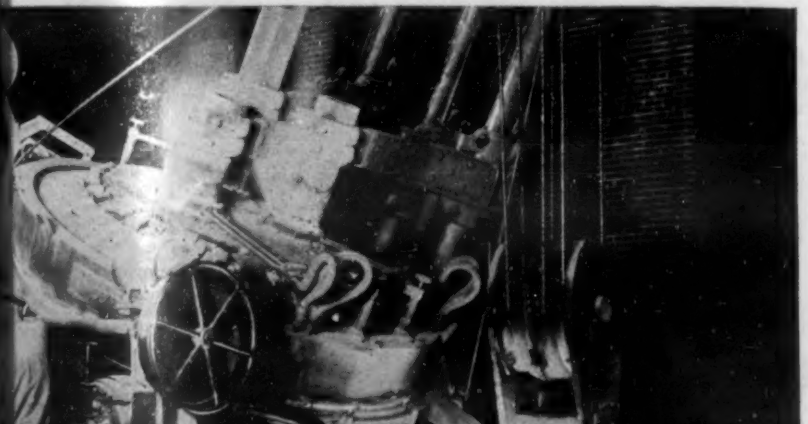
Change in Iron Practice

Increased iron capacity has a considerable effect on steelmaking. American practice has been built up on a 60:40 charge in the open-hearth, that is: 60 per cent steel scrap and 40 per cent iron, 5 per cent of which has been cold pig or iron scrap. With decreasing amounts of iron and steel scrap available operators are forced to continually raise the iron content of the charge until open-hearth shops

A tip from open hearth practice to help Electric Furnace men



A steel pipe set in 695 Plastic forms an electric furnace tap hole which helps to eliminate slag inclusions in the ladle.



695, a plastic high-magnesia refractory especially designed for open hearth tap holes and spout linings, is equally valuable in electric furnace practice.

● "We have a mean problem keeping slag inclusions out of the ladle," an electric furnace superintendent remarked to a Basic Refractories Field Engineer.

This Basic Engineer made a suggestion: "Why not replace that wide, open arch above the spout with a small tap hole similar to an open hearth tap hole? Then as the furnace tilts for pouring, the slag line will rise quickly above the outlet, and the steel can be poured with minimum danger of inclusions."

The idea sounded so good that the electric furnaces in this plant were changed immediately. The job was easy and took little time. The arch was bricked up and a 4" steel pipe set in, bedded all around with three inches of 695 Plastic. The spout also was lined with 695, and the bottom made flat and smooth directly under the tap hole to insure good drainage.

This simple change eliminated a source of slag inclusions and made it easy to hold an even flow of steel. Use of 695 Plastic insured long life for the tap hole and spout, because its extreme refractoriness resists the cutting action of steel and slag.

Basic Engineers are practical steel men, experienced in both electric furnace and open hearth practice. They are *your* refractories service men, ready to help you apply good refractories to maximum steel production for war.

MAGNEFER—Dead-burned dolomite for hearth and slag line maintenance.

SYNDOLAG—Dead-burned, rice size dolomite for maintenance.

BASIFRIT—Quick-setting magnesia refractory for new construction, resurfacing and maintenance.

OHIO MAGNESITE—Domestic dead-burned high-magnesia grain refractory, equal to Austrian.

695 PLASTIC—Strong plastic basic refractory for hot and cold repairs.

RAMIX—An air-setting, time-saving basic refractory for rammed hearths and cold repairs in open hearth and electric furnaces.

GUNMIX—A basic refractory with chemical bond, sized for use with a cement gun.

HEARTH PATCH—For deep hole patching and other quick repairs in the basic open hearth.

RAW DOLOMITE—Washed open hearth dolomite in rice size and standard ⅝-inch.

BASIC HEARTH
REFRACTORIES

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CLEVELAND, OHIO

may well expect to operate on 70 to 75 per cent iron. Operating, mechanical, and metallurgical difficulties can be expected from this change of practice.

Once in the furnace, the increased iron content causes an increase in the limestone required for fluxing its impurities.

Slag control will assist in the oxidation of carbon, manganese, phosphorus and silicon but 85 per cent of this oxidation is carried out by the reduction of lump ore or roll scale.

Increase in slag constituents will result in much greater slag volume which in turn will float on the bath in a deeper layer, requiring more fuel to penetrate the thick blanket and will require increased or entirely new facilities for its disposal.

In brief, the changes in practice from 40 to 75 per cent iron in the charge will result in approximately the following increases in raw materials for steelmaking:

Raw Materials	Tons per Year
Scale and ore	7,500,000
Limestone (or lime as CaO)	2,700,000
Refractories	225,000
Fluorspar	90,000

Furnace Practice

Present equipment consists to a large extent of stationary open-hearth furnaces which are not too adaptable to high-iron practice. Tilting furnaces are much more adapted to high-iron heats. While the change in iron content presents many difficulties, none of them are insurmountable.

On the other hand there are a number of methods for beneficiating or purifying the hot-iron constituent of the charge before pouring the metal into the open-hearth furnace and these are of substantial benefit in shortening steelmaking time and thus increasing ingot production.

Molten non-bessemer irons of moderate silicon content can be converted in acid bessemer vessels to a molten material of about the same composition as steel scrap. This material is suitable for charging into open-hearth furnaces either as cold scrap or as a molten charge. If charged in the molten state into large basic open-hearth furnaces of the tilting type, in which, after each tapping, a quantity of refined metal is retained, the metal may be refined and brought to a specified composition. Heats yielding 100 tons of steel ingots may be tapped from such furnaces in from 2½ to 3 hrs.

The quality of duplex steel has been the subject of a great deal of controversy. As steel for common purposes it passes the tests, meets all ordinary specifications and is satisfactory in service. For certain specific purposes, however, particularly those involving severe treatment in fabrication and manufacturing operations or in service, it exhibits peculiarities resembling in some measure those of bessemer steel which render the latter unfit for certain services.

High-iron practice has the advantage of converting the additional 7,500,000 tons of ore used in the open-hearth directly to 3,500,000 tons of steel. This ore otherwise would have to be processed by the blast furnaces.

A modification of the duplex process has been practiced for the past 2 yrs. at a large Pittsburgh open-hearth shop. Here hot iron has been blown down to mild or soft steel and cast into ingot molds. Stripped ingots are charged into the open-hearth as soon as possible to save sensible heat.

Ore and Hot Metal Processes

Up to a 60 per cent iron charge, the basic open-hearth process may be operated successfully along conventional lines. Reasonably good steel can be so produced and except for the effect of a larger quantity of eliminated metalloids originating from such large amounts of pig iron, differs little from steel made from the so-called "trade heat" charge of 50 per cent iron.

When the charge contains a larger proportion of pig iron than about 60 per cent, special methods must be employed in the elimination of the metalloids. Two distinct processes have been employed in the United States for working high-iron heats. These processes are designed to control the reactions and modify their physical effects in the furnace.

The first, based on the Talbot process, is carried out in large furnaces of the tilting type in which the heat is built up upon a residuum of refined metal by the addition, in increments, of the molten pig iron with sufficient iron oxide and lime with each increment for the satisfaction

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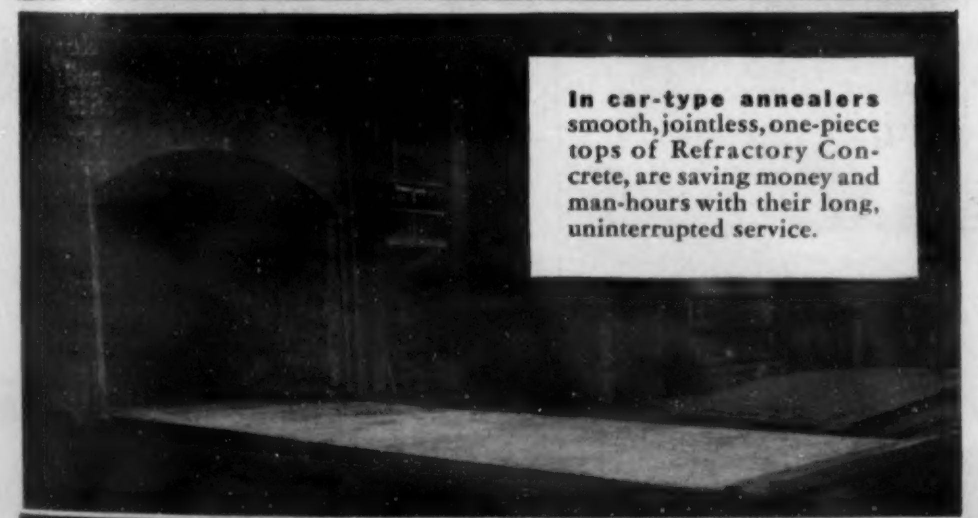
IN THE FURNACES, ovens and kilns of industry, Refractory Concrete, made with LUMNITE, confines and saves the heat that forges the instruments of war. It's in furnace walls, linings, and arches . . . in the arches of annealers and stress-relieving furnaces . . . the doors of foundry ovens and the tops of annealing cars . . . in door linings, ducts and flues of coke plants.

Time is being saved by using Refractory Concrete for construction and maintenance in a great variety of furnaces—from tool-shop tempering units to mammoth blast furnaces. Refractory *Insulating* Concrete is helping to meet the critical need for insulating refractories.

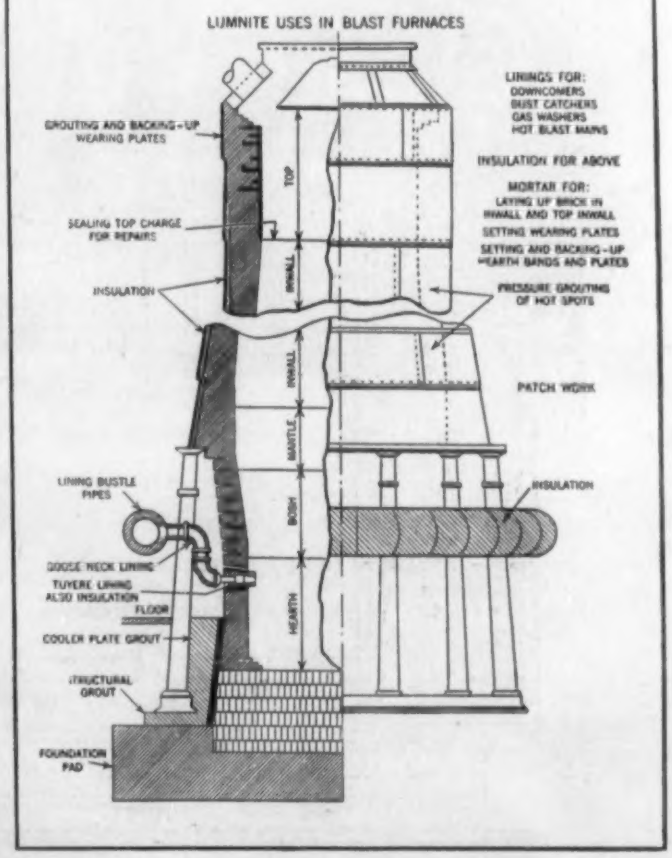
Our service forces are helping war plants make the most efficient use of LUMNITE. We will be glad to give you all available information on its application to your needs. The Atlas Lumnite Cement Company (United States Steel Corporation Subsidiary), Dept. M, Chrysler Bldg., New York City.

Tempering furnace lined with Refractory Concrete. This same plant uses LUMNITE in gas-fired boilers, the blacksmith shop heating furnace, and for a variety of special precast shapes. One installation leads to others because of economy in first cost and low maintenance records.

In this coke plant waste-heat flues and base slab for ovens are built with LUMNITE Heat-Resistant Concrete. This saved material and construction time.



In car-type annealers smooth, jointless, one-piece tops of Refractory Concrete, are saving money and man-hours with their long, uninterrupted service.



20 uses of LUMNITE in blast furnaces are indicated in this diagram. Major steel companies use Refractory Concrete to avoid delays in maintaining and reconditioning blast furnaces and auxiliaries. Free bulletin tells about many different installations.

LUMNITE FOR REFRACTORY CONCRETE

of the products of its refinement. After the heat is built up to the desired amount it is finished and tapped, leaving a residue of refined metal for the next heat. Deoxidizing and alloying materials are added to the ladle to avoid waste.

The second, the Monel process, may be carried out in stationary furnaces. A large part of the iron oxide is charged with the limestone or lime and covered by the scrap and cold pig iron. As the lime comes up, the reactions proceed with moderate activity. In this type of heat all of the steel is tapped out; if desired, additions may be made before tapping.

In both of the foregoing processes it is difficult to remove completely the larger amount of oxides produced in refining the pig iron. Nitrogen, however, is not introduced into the metal as it is in processes that include bessemerization.

Of the processes at present employed in the United States in the production of steel from charges that comprise a large percentage of pig iron, each results in steel having certain deleterious characteristics. The acid-bessemer and duplex steels contain more nitrogen and oxides, and the Talbot and Monel steels more oxides than steel made by the scrap-iron process in basic open-hearth furnaces. In the case of bessemer steel the detrimental effects of the oxides and of nitrogen are increased by the presence of phosphorus.

Metallurgical Considerations

Calculation of the metallurgy of active mixer processing as applied to pig iron produced in the United States and based on data from English practice, is given in a table.

Usually the reductions in the percentages of the metalloids from pig iron to mixer metal are accomplished partly by oxidation and partly by dilution with steel scrap. For instance, the carbon is reduced largely through dilution; the silicon and manganese largely by oxidation; while the sulphur and phosphorus reductions, the former by combination with slags and the latter less than half by dilution and the balance by oxidation, occur due to the presence of the basic mixer slag.

The active mixer can be operated in such a manner that the processed metal drawn from it has a uniform composition from ladle to ladle. This should be of considerable help to the open-hearth melter enabling him to avoid irregularities which result in longer heat time, more bottom repairs and poor quality of product. Also the early removal of excess amounts of the metalloids gives the metal a chance to clear itself of the products of the oxidations.

Metal processed in the active mixer has a higher temperature than that of molten pig iron, usually by about 150 deg. F. This elevation of temperature is accomplished in the mixer by the use of a comparatively small amount of fuel. To raise the temperature of a corresponding amount of metal in an open-hearth furnace would require considerably more fuel because of the higher general temperature of the open-hearth. Furthermore, the temperature of the processed metal entering the open-hearth furnace may be kept uniform from ladle to ladle.

Advantages of Processed Metal

By processing pig iron before charging it into open-hearths, ingots can be made from high-iron charges that are superior in quality to those produced by any of the processes that are or have been in use in the United States for making steel from such charges, and, with the single exception of the acid-bessemer steel, at a competitive cost.

A comparison of the estimated costs of ingots made from "trade heat" charges by the use of the active mixer and by the conventional open-hearth practice indicates a difference of about $1.00 per ton in favor of the active mixer practice. Steel of equally good quality should result from either practice.

The capital cost of an open-hearth plant including active mixers is only about 83 per cent as great as that of a conventional open-hearth plant of the same capacity. Eight conventional furnaces may be replaced by six furnaces and one active mixer.

The problems of the blast furnace operator should be greatly simplified by the introduction into the steel plant of active mixers. He would not be required to produce iron low both in silicon and sulphur, but rather to control the sulphur alone. This should result in fewer off-casts and less general trouble.

—W. C. Buell, Jr., J. R. Miller & H. W. Potter, *Steel*, Vol. 111, Aug. 17, 1942, pp. 78-82, 100-104.

Hardness Decrease in Rolling

Condensed from "Journal of Research, National Bureau of Standards"

A study was made to determine the influence of cold-rolling on the hardness properties of the surface layer of annealed 0.34 per cent carbon steel plate, initially surface-finished by three different methods —grinding, buffing, and metallographic polishing.

The test surface of the specimens used for most of the work was essentially free of surface decarburization. However, the metal adjacent to the corresponding surface of one series of specimens tested was decarburized to a depth of 0.01 to 0.02 in. Hardness tests were made on the specimens before and after rolling, with an elongated pyramidal-diamond (Knoop) indenter under loads of 50, 100, 200, 500, 1000 and 2000 grams, respectively. Hardness tests also were made on the same specimens with the Rockwell superficial hardness tester, by using a 15-kg. load on a 1/16-in. steel-ball indenter.

The experimental data show that the Knoop hardness number of the surface layer of the steel, distinguished from the underlying metal, was lower after cold-rolling reductions of 1 and 2 per cent than it was prior to rolling. Within the limitations of the tests, the results suggested that the most significant hardness decreases which accompanied the lighter degrees of rolling (1 and 2 per cent reductions) occurred in a layer less than 0.0003 in. in thickness.

The results obtained with the Rockwell superficial tester in no case revealed a lower indentation hardness for the specimens after cold-rolling than was obtained prior to rolling. In this respect the results obtained with the Knoop indenter under loads of 1000 grams (1 kg.) and 2000 grams (2 kgs.), respectively, were comparable. The test data suggest that the indentation hardness of the surface layer of the steel in the pre-rolled and rolled conditions was influenced by the nature of the initial surface-finishing treatment.

—Harry K. Herschman. *J. Res., National Bur. Standards,* Vol. 29, July 1942, pp. 57-67.

Making Alloy Cast Irons

Condensed from "The Foundry"

The most obvious method of economizing on the use of alloying elements is to adjust the base iron composition to produce as closely as possible the desired structure. Such practice requires a thorough knowledge of the effects of the alloying elements.

Secondly, in the absence of alloys the structure can be controlled by bare analysis for only one section or by the cooling rate. Therefore it must be known which section of the casting is the most important. Also base iron analyses are determined to a great extent by the melting unit.

Although low carbon irons have a definite place in industry, it has been found that requirements can be met as well, or even better, by making higher carbon irons and adjusting the silicon content to control the structure. Cast iron of 3.00 per cent total C is satisfactory for even heavy sections if the silicon is low. But low silicon irons are susceptible to variations in cooling rates. For this reason it has been common practice to use higher silicon. This reduces physical properties and causes porosity.

To eliminate this, close control over cupola and molding practice is required. Cupola control eliminates variations in chemical analyses so as to guard against undue chill. Wet sand, improper gating, etc. also cause chill.

The effects of sulphur, manganese and phosphorus also affect alloying economy if not held within proper limits. Sulphur should be below 0.12 per cent, manganese between 0.60 to 0.90 per cent. If the sulphur is between 0.04 to 0.06 per cent, manganese may be as low as 0.40 per cent. Phosphorus over 0.18 per cent causes shrinkage. Variations in chill depth, graphitic distribution and structure exist in irons of approximately the same analyses. They can be reduced by proper ladle additions. These variables are discernible by microscopic examination.

Modified structures are apparently aggravated by: (1) Excessive superheating over and above a given temperature for each type of furnace charge; (2) low carbon; (3) high percentage of steel; (4) low pouring temperature; (5) time at elevated temperature; and (6) rapid cooling. Modification also is thought to be affected by

wet or green ladles, scale or iron oxide on the ladle lips and by mold condition.

There are a number of theories used to explain action of ladle addition alloys. The three most widely accepted ones are: (1) Graphite nuclei theory which assumes that a ladle addition causes a seeding effect by furnishing submicroscopic nuclei of graphite for flakes to grow upon; (2) the silicate slime theory. This is similar to the first except that it assumes slime refractory particles which serve as nuclei for graphite crystallization; and (3) the degasification theory, based on the known change in the solubility of gas in molten iron with changing temperature.

The exact effect of any given ladle addition depends on the condition of the base iron and on the composition of the material added. Ladle treatment tends to eliminate any fluctuation in properties and chill by reducing or eliminating a tendency to modification. In this way it increases the average physical properties and reduces variations in such properties.

Although ladle addition materials have same general effect, they differ in composition and type. The graphitizing type of additions are suitable for applications requiring reduction in Brinell hardness and chill. An excess of graphitizing additions will cause shrink cavity, blow holes or porosity. Small amounts of vanadium and titanium reduce the chill when used as ladle additions in spite of being strong carbide stabilizers.

—R. G. McElwee and T. E. Barlow, *Foundry*, Vol. 70, June 1942, pp. 54-55, 141-146.

Cupola Blast Control

Condensed from "Institute of British Foundrymen"

A working theory of the cupola must depend on a complete understanding of the reactions taking place during melting. Because of the large number of variables concerned, because the speed of cupola melting is too great to allow many of the possible reactions to proceed to equilibrium, and because our means of observing the procedure of high temperature reactions are rather limited, such a theory has not yet been worked out. However, a study of the chemical and physical properties of the raw materials and products of the cupola allows certain conclusions to be made in the effort to develop the cupola into the precise melting tool we may expect of the future.

Certain Standards Necessary

To obtain uniform temperature and melting rate in the cupola, it is necessary to standardize: (1) The quantity and quality of the coke and metal charges; (2) the ratio of oxygen in the air blast to carbon in the coke; and (3) the conditions under which the oxygen and carbon are brought together.

The latter condition depends on the amount of surface of coke exposed to the air, the velocity of the air, and secondary reactions and catalysts that affect the rate and degree of completion of the reaction between oxygen and carbon.

In the foundry, these conditions may be considered constant and neglected when: (1) Coke size, porosity, and chemical analysis are held reasonably constant; in other words, when a satisfactory coke is bought from a dealer who can be relied upon to supply coke with uniform chemical and physical properties. (2) The melting zone and tuyere ratios are held constant, or when the melting zone is patched to correct size after each heat with a grade of refractory that will not burn away excessively, and when the tuyeres are kept free of slag. (3) Charging practice is uniform and no excessively large or very fine material is charged, *i.e.*, there should be no bridging (hand-ups) or channelling of charges. (4) Uniform kind and quality of flux is used, slagging is satisfactory, and no large amount of air escapes through the slag hole.

Coke-to-Metal Ratio

The coke-to-metal ratio that gives the best results may be found by experiment for a given coke and a certain metal charge Any change in coke quality or size or change in metal mix will require a change in coke ratio for optimum results. For example, an increase of steel in the mix, or the use of large pieces of iron scrap, will require more coke for melting.

When all other factors have been taken into account, the efficiency of cupola melting will be largely dependent on the oxygen-to-carbon ratio. Performance of a particular cupola as judged by quality and

temperature of metal at the spout, melting losses, and economy of coke consumption, is most satisfactory when a certain critical quantity of oxygen is supplied to burn the coke.

This quantity may be found by experiment, provided the operator can measure and control the amount of oxygen blown into the cupola for a given amount of coke. To determine it, one should first examine all losses of air in the entire blast system. Any serious and variable loss of air beyond the point of measurement of air blast will invalidate any readings obtained. One should then examine the method of measuring the air. A pressure gage gives valuable information about the conditions inside the cupola, but is of no use in determining the amount of air blown into the cupola.

A differential gage of the usual Pitot or orifice type will give the relative volume of air, and if correctly installed and calibrated, will come close to the actual cubic feet per minute. There are several air weight-type gages on the market that compensate for changes in atmospheric temperature and pressure and, excepting the single factor of humidity, give automatically a constant weight of oxygen.

Quantity of Moisture a Factor

The amount of moisture in the air also has an effect on the oxygen-to-carbon ratio. Compared with the effects of temperature and pressure, the influence of moisture is minor. Some foundries, however, are troubled with changes in atmospheric humidity. A few of these have installed air conditioners to ensure a constant moisture content in the air blown into their cupolas.

One foundry corrected for the amount of carbon required to dissociate the moisture in the blast by adding extra coke on days when the humidity was high. Coke to supply heat for the endothermic reaction and to heat the moisture in the air to reaction temperature was not taken into account.

Every foundry interested in maintaining quality and economy in connection with cupola melting practice should base air blast supply on a constant weight of oxygen. Supervision and control equipment for making the temperature-pressure correction, as outlined above, will prove an economical investment. Many foundry manuals give instructions for installing home-made volume meters, and the cost of a barometer and thermometer is nominal.

Where a critical type of casting is made, and where intelligent supervision and close control are available, compensation for humidity changes should also be made.

[*Three charts in the original paper give data in calculating the percentage of a normal blast, on determining the humidity for blast conditions, and on the total amount of coke necessary to compensate all factors.—Editor*]

—S. A. Herres & C. H. Lorig, *Inst. British Foundrymen*, Paper No. 749, pp. 10-12.

Practical Effects of Melt Conditions

Condensed from "The Foundry"

The first step in controlling changes in molten metal is to know the factors which influence these changes. Quantities of gas in metal cause shrinks, draws and porosity. Nitrogen, hydrogen and carbon monoxide are frequently present in metals.

The most common source of hydrogen in a furnace not using oil or gas, is moisture in the air. Carbon monoxide is present in all furnaces and may be present in iron or steel from dissolved oxides.

Another source of gas is that developed from moisture, sea coal facing or binder in the mold surfaces next to the metal. Considerable gas can be removed by a ladle addition of cold metal shot.

Removal of gas can be aided by: (1) Pouring the metal hot enough to permit excess gas to bubble out of the mold cavity; and (2) careful placing of vent and feed risers so that the last metal to freeze is in the riser, which will tend to draw the gases from the casting.

Silicates, oxides, sulphides, etc. in excessive amounts cause flaws and hot shortness, and impair physical properties. Silicates separate from the metal with the hot fluid metal and slag. Oxides are removed by deoxidation just before pouring.

It is important not to deoxidize too long before pouring, so that the hydrogen is not absorbed by the metal in the furnace. Sulphides are made ineffective by the presence of adequate manganese sulphides instead of iron sulphides. Gases and solid inclusions are better removed from the mold when the metal is hot.

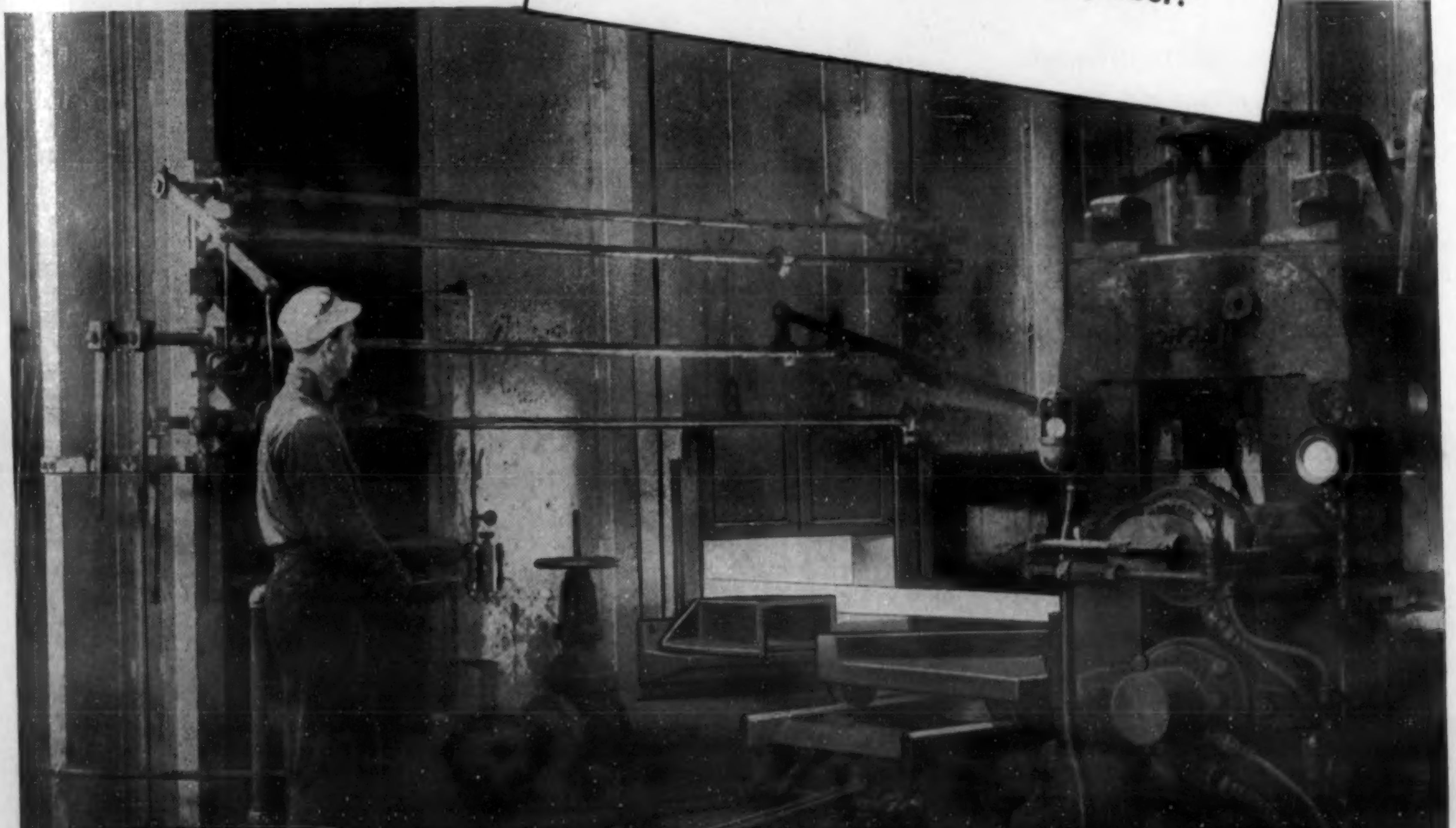
Every 20 seconds I start a mile of rod!

"Sure I'd like to get in the fight with a gun in my hands . . .

"But then I get to thinkin' . . . maybe I'm in the fight right here, working this switch. Every 20 seconds I start a mile of rod . . . that's about 173 miles of rod an hour . . . good for around 84,000 miles of barbed wire every week!

"Match that one, Schicklgruber!"

R-105



MORGAN CONSTRUCTION COMPANY • WORCESTER, MASS.

Steel and Iron

Steel at high temperature readily absorbs gases. They may be reduced by melting under oxidizing conditions. After melt-down, the heat should be brought up to temperature rapidly.

Pouring temperatures (2750-3000 deg. F.) depend upon composition, type and size of castings. Large castings are poured on the cold side to prevent attack of the refractory walls, while small castings are poured on the hot side to insure filling of the mold.

For steel, aluminum addition, particularly if castings are poured in green sand, prevents pinholes. Small additions may impair ductility.

For gray iron an optimum range of 2700-2900 deg. F. is recommended. Melting at higher temperatures tends to produce superheated structure, characterized by fine dendritic graphite.

Other factors that tend to produce a fine dendritic structure are: (1) More rapid freezing of light sections; (2) pouring temperatures of less than 2500 deg. F.; and (3) the more hypoeutectic irons. To minimize this, ladle additions of silicon are made, accompanied by nickel and molybdenum for machinability and strength Ferro-silicon of from 0.20 to 0.50 per cent is often used.

The optimum effect on gray castings regarding soundness and mechanical properties are secured with mold pouring temperatures between 2600 and 2750 deg. F. Except for the softest types of iron, no gray iron castings should be poured with metal that has begun to scum over or oxidize on the surface.

Alloy additions should be made in the furnace. Ladle additions should be made with regard to maintaining the proper temperature. Each 1 per cent addition of solid metal lowers the molten metal temperature 30 deg. F.

Hydrogen absorption is higher in electric and air furnaces than in the cupola. To secure high temperatures at the mold requires high temperatures (2800-2950 deg. F.) at the furnace. Decreasing carbon or silicon lowers fluidity, while fluidity increases with cleanliness.

Non-ferrous Alloys

Copper alloys, like other alloys, must be deoxidized just before pouring. This is done by using phosphorus and zinc in suitable amounts.

To reduce variations in molten metal conditions, the following points are pertinent: (1) Hydrogen can be held to a minimum by preventing its occurrence and by keeping the metal on the oxidized side; (2) carbon monoxide can be prevented by removal of iron oxides with calcium, silicon or aluminum; (3) degasifying can be done by adding small amounts of solid metal at tapping time.

Also, (4) clean metal well-separated from slag is the best assurance of clean castings; (5) temperature should not be too high to cause excessive gas absorption; (6) proper pouring temperatures reduce trapped gas and inclusions; and (7) maximum convenient pouring speed should be used.

—Frederick G. Sefing, *The Foundry*, Vol. 70, July 1942, pp. 78-79, 16?-167.

Lead Melting Furnace

Condensed from "Industrial Gas"

Complete automatic operation with safety features characterize a lead-melting furnace described here. Starting from cold, the furnace has actually melted 1000 lbs. of lead in 45 min., consuming 475 cu. ft. of 540 B.t.u. gas. It is estimated that a full charge of 5000 lbs. can be melted from a cold start in 87 min., with gas consumption of 920 cu. ft.

Ingots of metal are charged from the side of the furnace where the floor is higher than on the discharge side. Rapid heating and fuel economy are promoted by $4\frac{1}{2}$ in. of insulating firebrick for lining the furnace, this being backed by $2\frac{1}{2}$ in. of Sil-o-cel insulating brick.

The furnace setting was designed by engineers of the Brooklyn Union Gas Co. to fit a cast iron pot. All pipe connections between the main burners and pilots are made under the furnace, which has a false bottom not far below the burners. The blower and combustion controls are in a pit beneath the furnace.

Molten metal is drawn off through an outlet in the bottom of the pot, this outlet being fitted with a valve which is controlled by a hand wheel located conveniently.

—F. K. Whiteside, *Industrial Gas*, Vol. 21. August 1942, p. 7.

Processing and Fabrication 2

FORGING, FORMING, MACHINING
HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining • Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering • Heating Furnaces, Refractories, Fuels and Auxiliaries • Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting • Cleaning, Polishing, Buffing, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing • Die Casting • Powder Metallurgy

CONTENTS

Cold-Forming Duralumin Sheet

Condensed from "Canadian Metals & Metallurgical Industries"

Die-pressing has been adopted for the outer panelling and airframe parts in mass production. The "Alclad" forms of aluminum-coated duralumin are generally more troublesome in the press shop than are the uncoated alloys, owing to the softness of the aluminum coating. Any breakdown in the lubrication of the blank involves grave danger of fouling of the dies, with consequent loss of efficiency due to excessive die-re-dressing.

Pressing difficulties common to both coated and uncoated alloys fall, in general, into 2 categories: (a) those associated with the fundamental properties of the alloys, and (b) those caused by defects in the alloys.

Fundamental properties are: (1) Effect of heat-treatment, (2) low ductility, compared with other deep-drawing materials and (3) high "spring-back" compared with deep-drawing materials.

Heat Treatment

It is advisable to solution-heat treat the duralumin blanks and to carry the forming operations immediately afterwards. Unless the blanks are re-solution-heat-treated, trouble is invariably experienced with tearing at the edges, where work-hardening has resulted from the shearing or blanking operation.

Considerable distortion attends the quenching of large blanks. A large proportion of blanks from the salt bath are passed through a roller-leveller. Roller-levelling consists of passing the blank through staggered rolls so that it receives a series of small reversed bends diminishing in amplitude.

This method of flattening work-hardens the material to a smaller degree than do stretching or cold rolling. The roller-levelling of solution-treated duralumin sheets impairs their cold-pressing properties by reducing their ductility and increasing their tendency to "spring-back." The degree of impairment apparently varies with the severity of the roller-levelling operation.

Experiments indicate that the tensile properties of the material show that 0.1 per cent proof stress figures are raised progressively by roller-levelling. The effect is more pronounced in the case of thick sheets than in that of thin ones.

Distortion may be minimized: (1) By delaying quenching until the metal has cooled to a temperature at which its strength is adequately increased, or (2) by ensuring that the quenching effect is distributed uniformly over the whole sheet.

In general, the effect of delayed quenching is to lower the ultimate strength and proof stress of the duralumin-type alloys and to lower their resistance to intercrystalline corrosion. The delay in quenching can be so regulated that the mechanical properties still comply with the relevant specification. The delay that is necessary to produce a worthwhile reduction in distortion has a definitely adverse effect on the resistance of ***uncoated*** duralumin-type alloys to intercrystalline corrosion, the corrosion-resistance of aluminum-coated alloy

after similar treatment may be adequate.

Uneven cooling during quenching can be avoided by: (a) rapid immersion, (b) hot-water quenching, and (c) fog- or spray-quenching. Immersion in oil produces distinctly less distortion than immersion in water. But where the heating has been carried out in a salt bath, the fire hazard involved by the introduction of molten nitrate into the oil, the rapid contamination of the oil bath, and the difficulty of removing all traces of nitrate from the oily surface after quenching are objections to the employment of this method of quenching.

Certain alloys differ from ordinary duralumin in that the age-hardening is incomplete and takes place much more slowly at room temperature. With these alloys, the maximum tensile properties are developed only after heating the solution-heat-treated metal at a slightly elevated temperature for a period usually about 18 hrs. The temperature depends on the particular alloy concerned.

The aging treatment gives rise to two complications in the pressings. In the first case, unless the thickness of metal is above 0.08 in. there is a serious risk of distortion during the process, possibly necessitating adjustment of shape when they are in their hardest condition. In the second case, this heat treatment seriously impairs the resistance of these alloys to intergranular corrosion. The long time involved in the aging treatment is extremely costly, as special forced-air-circulation furnaces are necessary to carry out the operations and a considerable extra amount of shop space is required.

Refrigeration

Storage of the solution-heat-treated blanks in a refrigerator delays the age-hardening process and the permissible delay is governed by the storage temperature. Refrigerated trucks permit the transportation of small batches of material to the press room. The small amount of distortion associated with spray-quenching indicates that this method could be applied with advantage to intermediate solution-heat-treatments.

For the production of a normally difficult pressing, after the blanking operation the metal is given a solution-heat-treatment involving a water-quench from a predetermined temperature. If a refrigerated cabinet is available the blanks are kept in it until required; if none, they are formed with a minimum of delay. Whenever annealed material is used a final solution-heat-treatment is necessary to develop the full mechanical properties required by specification.

Press Work

As a result of the distortion, the stamping usually requires a subsequent adjustment by hand work or by means of a further press operation. While the various heat-treatments have a profound effect upon the values for the 0.1 per cent proofstress and ultimate stress, the percentage elongation remains practically unchanged. This indicates that deep-drawing properties cannot be judged solely from consideration of the elongation figure obtained in the tensile test.

The extent of the elastic recovery that follows the maximum deformation of the material when the punch reaches the bottom of its stroke depends upon: (a) the value of Young's Modulus for the material, (b) the nature of the forming stresses and (c) the value for the elastic limit of the material.

"Spring-back" difficulties have been overcome by carrying the pressing almost to full depth under conditions of easy flow of metal through the blank-holders. The blank-holder pressure is then readjusted to restrict further slip, and the punch taken to the bottom of the stroke.

In this manner the amount of stretching necessary to minimize "spring-back" is obtained, together with the easy flow through the blank-holders in the initial stages of the draw which is necessary to prevent splitting the metal. "Spring-back" may be still further reduced if the pressing is solution-heat-treated immediately before the final forming operation.

Duralumin-type alloys are very easily scratched during handling and care must be exercised to avoid this, especially during heat-treatment operations. Splitting troubles during the former operations and can often be traced to scratches or other surface defects.

A fairly reliable indication of the deep-drawing properties of duralumin-type alloys is to be found in the microstructure and the value of percentage elongation obtained in the tensile test carried out on freshly solution-heat-treated material.

—J. C. Arrowsmith, K. J. B. Wolfe & G. Murray, *Can. Metals & Met. Inds.*, Vol. 5, July 1942, pp. 201-205.

Shell Case Manufacture

Condensed from "American Machinist"

Incoming brass discs are inspected for hardness and grain structure as well as for visual defects. In the cupping operation, the die is Haldi steel (high C, high Cr) while the punch is carburized Atha Pneu steel (low Cr-W), chromium plated to a depth of 0.0002 in. for a distance of 5 in. from the end. The blank is then annealed in annealing basket of 25 Cr-20% Ni steel at 1100 deg. F. for 2 hrs. After annealing, one case in every 5000 is checked for grain size (0.060 to 0.1230 mm. at 75X). Pickling after annealing is done in a dead-lined tank with to 5% H_2SO_4 at 175 deg. F.; the cases are then carefully washed.

The four drawing operations use carbide inserts in steel dies with hardened and ground punches of carburized Atha Pneu, chromium plated on the end for a distance slightly greater than the length of draw. The cases are annealed, and washed after each drawing operation. After trimming, the cases are headed and indented. The heading punch is an 0.28 C-4.4 Ni-1.6 Cr-0.4% Mo steel, carburized and hardened to Rockwell C 48, while the die ring is Sanderson Special No. 5 (carbon tool steel, 1.2% C) and the first and second bumpers are Haldi. The primer hole is pierced, then the cases are dipped in a 950 deg. F. saltpeter bath for 2 min. to anneal them before the ends are tapered in a carburized steel die. The cases are then machined, inspected, and packed.

—*Amer. Machinist*, Vol. 86, May 28, 1942, pp. 521-528.

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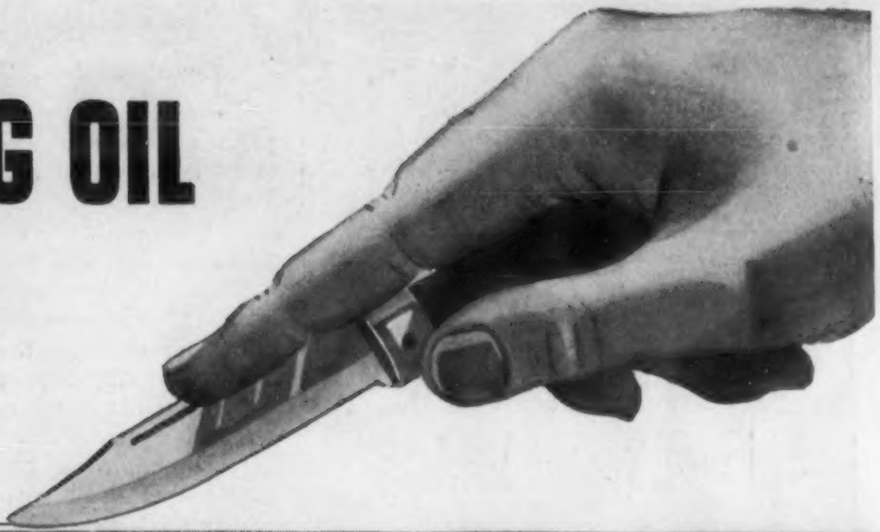

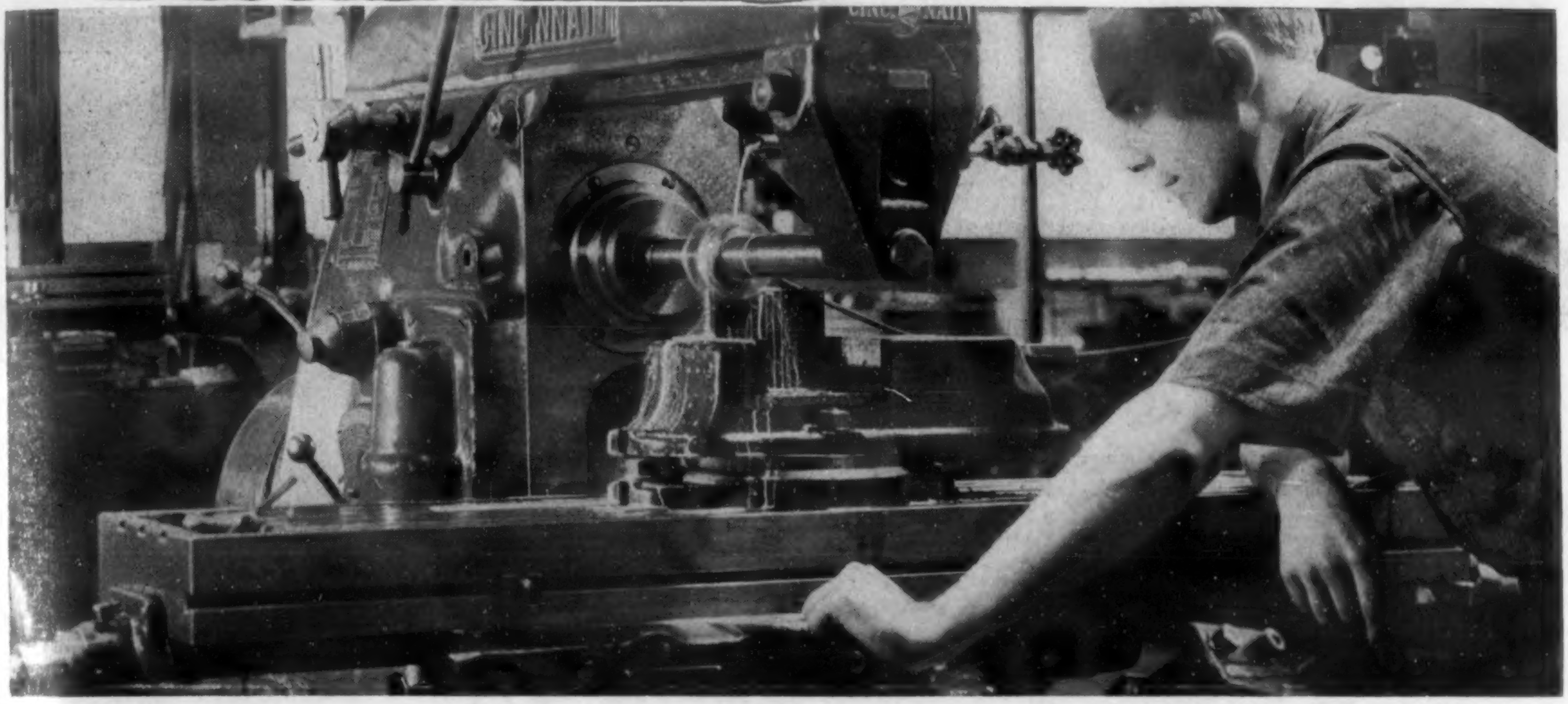

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A LUBRICANT FOR EVERY INDUSTRIAL NEED

Fine Finish and Tool Life

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To use molybdenum efficiently in the place of tungsten and cobalt in cutting tools it was found necessary to change the design of the tools and to sharpen and resharpen them by precision machine-ground and honing methods, rather than by hand.

Research by the Wright Aeronautical Corp. resulted in the production of a satisfactory single point cutting tool for many rough turning operations.

Machine-ground and honed tools showed a much improved tool life, over hand ground ones and a new production method was worked out. Tests were conducted on various molybdenum high speed tool steels to ascertain which of many brands would give the best tool performance. All tools were used on production runs. A final and more accurate check by break down tests is now being made.

The tool design used is as follows: 13 deg. side rake, 5 deg. back rake, 6 deg. front and side clearance, 1/16 in. nose radius, and a step-type chip breaker design adaptable to the application. The chip breaker was ground to the same positive rakes to deflect chips from the point of the tool, and featured a design with a depth of 1/16 in. and a 1/16 in. shoulder radius on all sizes. The width at the nose end varied from 7/32 in. on a 1 in. square tool, and a 5/32 in. on a 5/8 in. tool.

The object was to distribute the force necessary to break the turnings into discontinuous chips which take up less space and eliminate the wrapping of chips around the work. The shear angle of the chip breaker curls the chip away from the tool point. There is no protracted period of contact and thus less transfer of heat.

Tool life and performance proved to be increased from 10 to 20 times with machine-ground and polished tools, due to the keenness of the cutting edge and the smoothness of the end flank and chip breaker groove of tool. The precision ground tools may be honed to a finish of 1.0 to 1.5 micro-in. r.m.s. although 3.0 to 3.5 micro-in. r.m.s. is satisfactory. For this a 10 x 2 x 2 in. Alundum vitrified wheel (Norton 38220-L9BE) was used. The finishing was done dry on an Ex-Cell-O grinder in about 1 min.

Chip breakers are ground with a positive rake and then polished dry with a fine silicon carbide wheel to a finish of 2.0 to 2.5 micro-in.

For rough grinding the chip breaker groove, a Norton 7 x ½ x 1¼ in. Alundum wheel was used (Norton 3846-18BE) and for the honing a 7 x ½ x 1¼ in. Crystolon silicon carbide wheel (Norton 37320-J8L).

Tools were semi finished ground, wet on the flank and end, one at a time in an Oliver grinder with a specially formed cam or guide permitting the radius and both clearance angles to be ground at one time. The wheel used is a 7 x ½ x 1¼ in. Alundum vitrified wheel (Norton 3846-L5BE).

Since the fall of 1941, 100,000 pieces of 40 different forgings have been machined, using this tool design on about

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20 different brands of high speed tool steel. Tests were continuous without change in production and set-up, on various rough turning operations on both automatic and hand turret lathes. Only H. S. S. tools with a hardness between Rockwell C-61 and C-65 were used. They were set on center to axis of the work and at 90 deg. to the cut. As they were re-ground they were brought back to the center by shimming up. The brand of cutting oil and the oil flow on individual machines were kept constant.

Precision grinding permits the tools to be ground in a uniform and consistent manner to definite standards, making possible production in substantial quantities with consequent reduction of cost. It is possible to establish a definite tool change period to avoid running a tool to breakdown. The bits then require very little grinding so there is economy of material and grinding time. Due to less frequent use there is also a saving in grinding wheels.

Maintaining the condition of the tools is important. The cutting edges must be protected. They should be wrapped and stored in centralized tool cribs until placed in use.

—Carl J. Wiberg and Wesley K. Heath, *The Iron Age*, Vol. 150, July 23, 1942, pp. 33-37.

Plated Aluminum

Condensed from "Metal Finishing"

Until a few years ago aluminum could not be plated with any metal except nickel. Shortcomings in the anodic coating process for plate adhesion, which resulted in the above limitation, have now been overcome. As a result aluminum can be plated with any of the plateable metals. Cyanide baths can be used if the temperature or pH are not too high.

Cyanide copper plated onto aluminum has good enough adhesion so that it is possible to effect fabrication by soldering. Cadmium is plated on aluminum for corrosion resistance and as a surface for soldering. Aluminum plated with silver has increased conductivity for high frequency currents, a factor of importance in radio parts.

Aluminum, directly brass plated, can be bonded to rubber. The strength of the bond thus established between the aluminum and the rubber is limited only by the mechanical strength of the rubber. This application has found use in the production of bullet-proof aluminum gasoline tanks.

Adhesion of plated coatings to high strength aluminum alloys (durals) is not as good as to purer forms of aluminum (2S and 3S), but progress has been made in this direction.

Where wear resistance of aluminum parts is required either chromium or the newer hard nickel may be used. The greater ductility of hard nickel may be an advantage in some applications. Hard nickel has been used on top of aluminum pistons for Diesel or gasoline engines to prevent oxidation of the aluminum, and experiments indicate that hard nickel plated over the entire piston surface reduces wear to a remarkable degree.

—Raymond F. Yates, *Metal Finishing*, Vol. 40, June 1942, pp. 295-296.

Air Hardening Forging Die Inserts

Condensed from "Heat Treating and Forging"

A recent development has been the replacement of the predominantly nickel and predominantly tungsten types of die steels by air-hardening 5 per cent Cr steels for die inserts. Steel "B" contains 0.35 C, 0.35 Mn, 1.0 Si, 5.0 Cr, 1.75 Mo and 1.35 percent W. Steel "S" contains 0.95 C, 0.60 Mn, 0.20 Si, 5.0 Cr, 0.25 V and 1 percent Mo.

Steel "B" can be applied successfully on difficult sections where sharp corners, deep cavities, or wedging actions are present. The use of "S" is limited to simple shapes and shallow impressions.

The price of "B" or of "S" is about double that for die-block material, but the smaller amount used in an insert and the greater ease of handling eliminates the difference. These steels cost about half what high-tungsten hot-work steels do.

Insert dies are made by machining in the annealed condition to the necessary contours. Two or 3 impression dies are usually selected where the weight of the forging will not exceed 8 lbs. At least 1½ in. of metal should be provided between impressions and between the edge of the insert and the nearest impression, as well as from the bottom of the deepest impression to the bottom of the insert. In some cases, the insert is locked directly into the sow block, while in others, a slot is machined into a used die-block which is used as a holder and the whole unit keyed into the sow block in the usual manner.

Sometimes, particularly with press-forging die inserts, it is desirable to shrink the insert into a heat-treated holder. This is done by heating the holder to about 800 deg. F., dropping in the heat-treated and polished insert, which should be ready for use, and cooling the whole unit so that the contracting holder grips the insert.

Heat treating of these insert dies must be done very carefully. Unless a controlled atmosphere furnace is available that will assure scale-free and decarburization-free hardening, dies of either "B" or "S" should be wrapped in 3 thicknesses of heavy brown paper, and completely surrounded with at least 1½ in. of cast iron chips in a container. One-half in. of cast iron dust should be sprinkled on top of the pack.

This is then loaded into a furnace operating at 1400 deg. F. When the pack reaches this temperature, the furnace is raised slowly to 1800-1825 deg. F. The whole pack is held at this temperature for about 30-45 min. The container is then removed from the furnace and the dies from the pack.

During heating, the paper chars. The charred paper possesses sufficient strength to keep any chips from contact with the dies, thus preventing them from fusing to the dies and assuring a very clean surface.

The dies should be air-cooled in a light fan blast until they can be handled with the bare hands. Then they should be tempered by heating "S" to 1175-1200 deg. F. and "B" to 1075-1100 deg. F. Tempering time should be at least 4 hrs. at the temperature of the work. The hardness of "S" will be 46-47 Rockwell "C" and of

"B" 45-47 Rockwell "C." Little distortion occurs during the heat treatment.

Light hand polishing should put the dies into condition for use. The bottom of the insert and the bearing surface of the holder should be flat to assure 100 per cent bearing and support.

Die failures that start at the bottom of the die can be greatly reduced by the use of soft-backed dies. To soften the back, the tempered insert is reheated to 800 deg. F., the bottom is immersed not more than ½ in. in a lead bath at 1000 deg. F., the bath is raised to 1450 deg. F., and the dies held at this temperature for 2-3 hrs., after which they are cooled in still air to room temperature.

This method should not be used on inserts where the distance from the bottom of the impression to the bottom of the insert is less than 2½ in. This treatment lowers the hardness of the bottom of the insert to 36-38 Rockwell "C" for "S" and 28.5-30 Rockwell "C" for "B."

—H. E. Replogle, *Heat Treating & Forging*, Vol. 28, May 1942, pp. 225-227, 234.

Carbide Tools on Large Machines

Condensed from "Aero Digest"

Until recently few considered carbides on large machines such as boring mills and engine lathes, because most machines of this size were not run on a continuous basis nor did they have the power or rigidity for high speed operation.

Production requirements have necessitated a revision of this viewpoint. Present day carbide tools are satisfactory not only for cast iron and non-ferrous materials, but also for harder and tougher steels. They can also be used for the whole gamut of interrupted cuts.

Factors which have contributed to this larger field of use are: 1. Increased knowledge of proper feeds, speeds, and improved clamping fixtures; 2. better determination of shank and tip sizes for heavy cuts; 3. development of suitable tool shapes (for example the negative back rake for interrupted cuts on large work); 4. adoption of central grinding rooms for reconditioning tools.

Advantages of carbides on large machines are: 1. Increased cutting speed to give better finish without reduction in rate of metal removal in spite of lower feeds (usually below 0.030); 2. lighter feeds to permit less cumbersome fixtures; 3. parts do not have to be chucked or fastened as securely, thus avoiding distortion; 4. longer tool life per grind reducing down time; 5. ready machining of harder materials, such as armor plate castings and heat-treated alloy steels of 300 to 500 BHN; 6. tools do not have to be checked so frequently for changing dimensions due to wear.

Introduction of carbide tools has often brought about other improvements in shop practice including "planned" cutting (adjusting cuts to remove stock in the fastest way), adoption of tool setting devices for quicker set up, and greater usage of machine dials as check on cutting.

—F. W. Lucht, *Aero Digest*, Vol. 41, Aug. 1942, pp. 156, 191.

Heat Treating Steel Forgings

Condensed from "Steel"

All heat treatments may be classified according to whether: (1) steel is heated to a temperature above the critical range, then cooled in some predetermined manner, or (2) temperature attained lies below this level.

The iron-carbon alloys are sharply distinguished from all other metals and alloys by the readiness with which their physical characteristics may be related to desired specifications by heat treatment.

There are only two types of grains that have any practical influence on the properties of steel: Austenitic grains that are stable above the critical range, and ferritic grains, existing at normal atmospheric temperature.

The maximum degree of refinement occurs on passage through the critical range; the higher the temperature reached and the longer the time at that temperature, the larger the austenitic grains tend to become.

The rate of grain growth rises rapidly in the "coarse-grained" steels and tails off toward a limit; in "fine-grained," growth is small in the early heating stages through the stable austenitic range and later rises abruptly to high levels.

Affected by the size of the austenite grains are hardenability and machinability. The coarser the grain, the deeper the effects of the quench penetrate. Rough cuts are more easily taken on coarse grained steel, but fine-grained finishes better. The size of the ferritic grains which form within the original austenitic grain boundaries influences the hardness, toughness and strength at ordinary temperatures—the smaller these grains, the harder, tougher and stronger the steel. Deep drawing qualities, creep strength and electrical properties are also affected. Size of the ferrite grains appears to be related to the size of the austenitic grains if the cooling rate is held constant.

In heating steel for hardening, do not heat much above the top of the critical range lest the structure be coarsened without increase in hardening power. Danger of warping and cracking increase also.

Tensile strength of both hypo and hypereutectoid steels, particularly alloy steels, increases with increase in the duration of heating since the solution of the carbides is not instantaneous.

When the cooling rate is sufficiently slow, transformation occurs at the normal 1292 deg. F. and the pearlitic structures characteristic of annealed steels appear. Speeding the rate, the pearlite grain becomes finer, the transformation temperature dropping more rapidly until its eventual disappearance at relatively high levels and its reappearance at much lower temperatures. This discontinuity marks the boundary between structures of the pearlitic type and those of the acicular or martensitic type.

There are only two readily distinguishable mechanisms by which austenite transforms and they relate to the temperature of that portion of the austenite undergoing transformation. The first, characteristic of annealing and normalizing, involves the simultaneous formation of ferrite and carbide layers directly from austenite by a steady encroachment of roughly parallel

plates or lamellae upon the receding austenite boundary. The latter, acicular reaction, characteristic of hardening steel, is marked by the successive abrupt formation of flat plates of supersaturated ferrite along certain crystallographic planes of the austenitic grains.

During this action the supersaturated ferrite begins to reject carbide particles at a rate depending on temperature of transformation. If the latter lies below 300 deg. F. as a result of rapid quench in a cool bath, the steel, if immediately lowered to atmospheric temperature, exhibits a martensitic form and consists of highly supersaturated, strained ferrite in which the precipitation of the carbides has not occurred extensively.

If this martensite is reheated, many carbide particles are precipitated as troostite and sorbite. But no amount of reheating, short of a return to the austenitic condition and subsequent cooling through the critical range, will produce a lamellar distribution of the ferrite and the carbide, characteristic of the pearlitic reaction.

—Arthur F. Macconochie, *Steel,* Vol. 111, Aug. 17, 1942, pp. 74-76, 110-113.

Heat Treatment and Grain Size

Condensed from "Journal of Research, National Bureau of Standards"

A study was made of the influence of initial structure and rate of heating on the grain sizes at 1475 and 1600 deg. F. of a high-purity alloy of iron and carbon and two plain carbon steels each containing about 0.5% C. The two steels were commercial heats which differed principally in the amounts of alumina and aluminum.

The steel with the lower percentage of aluminum was produced under conditions which resulted in non-control of the austenitic grain size, whereas the other heat was produced under conditions intended to control the grain size. The different initial structures (that is, the structure that existed just prior to heating to the temperature establishing the grain size) consisted of either coarse pearlite, fine pearlite or spheroidized cementite in the Fe-C alloy and either coarse pearlite, medium pearlite, fine pearlite, bainite, or spheroidized cementite in each of the commercial steels.

Wide variations in the rate of heating were obtained by plunging small specimens into a lead bath or by heating them in vacuum. Except for the specimens heated in lead (most rapid rates), the rate of heating was taken as the average rate to heat from 1325 to 1450 deg. F., which included the transformation-temperature range. Variations in the initial structure of the Fe-C alloy had no appreciable effect on the grain size at 1475 or 1600 deg. F.

Although the initial structure had some influence on the grain size of the commercial steels, no definite correlation was found between the grain size and the interlamellar spacing of pearlite, or the form and distribution of carbides. The rate of heating had a marked influence on the grain sizes at 1475 and 1600 deg. F. of the Fe-C alloy. At each temperature relatively fine grains were produced by rapid heating and coarse grains by slow heating.

With some of the initial structures, the rate of heating affected the grain size at 1475 deg. F. in the noncontrolled and con-

trolled steels, and at 1600 deg. F. in the controlled steel. In all cases where the rate of heating influenced the grain size of the commercial steels, the finest grains were obtained with slow rates, the reverse of the relation found with the Fe-C alloy.

—T. G. Diggers & S. J. Rosenberg. *J. Res. National Bur. Standards*, Vol. 29, July 1942, pp. 33-40.

Hard Nickel Plating

Condensed from
Proceedings of the Electrochemical Society

In 1938 one of the authors showed that thick deposits of hard nickel could be made from a nickel ammonium sulphate bath described by Macnaughtan and Hothersall [*Trans.* Faraday Soc., *Vol. 24*, 1928, page 387]. However, several features of the process were unsatisfactory. The anode current efficiency dropped off above current densities of about 30 amps. per sq. ft. The deposits had a laminated structure and in many cases layers separated when subjected to mechanical abuse. The hardness could not be closely controlled. There was a pronounced tendency for treeing and the pH was not stable.

These unsatisfactory features are eliminated by use of a bath of the following composition:

Nickel sulphate ($NiSO_4 \cdot 7H_2O$) 180 grams per liter
Ammonium chloride (NH_4Cl) 25 grams per liter
Boric acid (H_3BO_3) ....30 grams per liter

By suitable selection of current density, temperature, and pH the hardness can be controlled. Thus, operation at a current density of 50 amps. per sq. ft., a temperature of 120 deg. F., and a pH of 5.9 gives a deposit having a Vickers hardness of 500. Higher temperatures, lower pH values, or lower current densities give softer deposits.

The hardness of the deposits varies but little with thickness. Typical tensile properties of hard nickel deposits from this bath are: Ultimate tensile strength, 157,000 lb. per sq. in.; elongation, 6% in a gage length of 2 in. Annealing these deposits results in softening. Heating for 18 hrs. at 600 deg. F. reduced the hardness from about 400 to 300 and the tensile strength from about 150,000 lbs. per sq. in. to about 80,000 lbs. At ordinary temperatures the deposits retain their hardness indefinitely.

If the basis metal is properly cleaned, excellent adhesion of deposits is obtained. For example, with a deposit plated on SAE 1340 steel, an adhesion value of 94,500 lb. per sq. in. is reported with the failure in the steel. With 3.12% C cast iron as the basis metal, an adhesion value of 24,400 lb. per sq. in. is obtained, with the failure in the cast iron. A modified Ollard test was used for the adhesion measurements.

Hard nickel deposits can be built up much faster than chromium deposits and at lower current densities. Rates of deposition as high as 0.005 in. per hr. have been used. The good behavior of the bath has been extensively confirmed by operation of a 100-gal. tank at frequent intervals over a period of several years. The work done has included application of heavy deposits to the surface of rolls, the salvaging of worn parts, the coating of miscellaneous machine parts for resistance to abrasion, and a small amount of electroforming.

—W. A. Wesley & E. J. Roehl, *Proc. Electrochem. Soc.*, Preprint 82-1, Oct. 1942.

Flame Descaling

Condensed from "Steel"

Descaling with an oxyacetylene flame is faster, more economical, and generally more suitable than pickling, sand-blasting, wire-brushing, and grinding for descaling blooms, billets, slabs, and plates. It is also replacing bobbing, tumbling, sand-blasting, grinding, and in some cases, machining for descaling forgings and castings. Many alloy steels, small billets, light plate, sheets, and some forgings have a scale that is not easily removed by any method. However, encouraging results have been obtained by using flame descaling for removing this type of scale.

Flame descaling is based upon the principle of differential expansion achieved through a sudden heating of the surface layer of the scale. For most effective and efficient flame descaling, heating should be so fast that a superficial layer is raised to an extremely high temperature before any of the heat has a chance to soak through and cause the scale to fuse before it pops off. Differential expansion oc-

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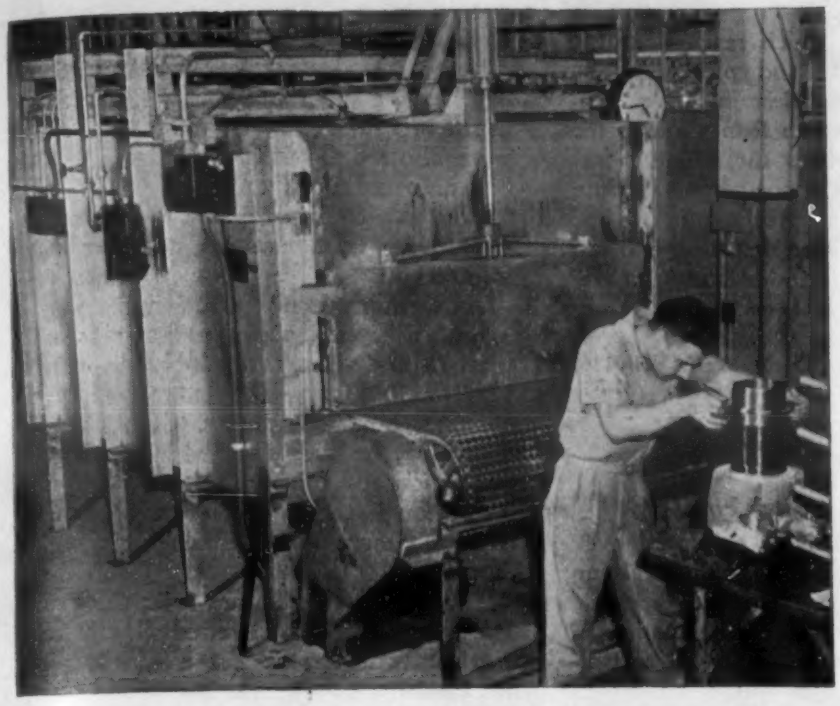

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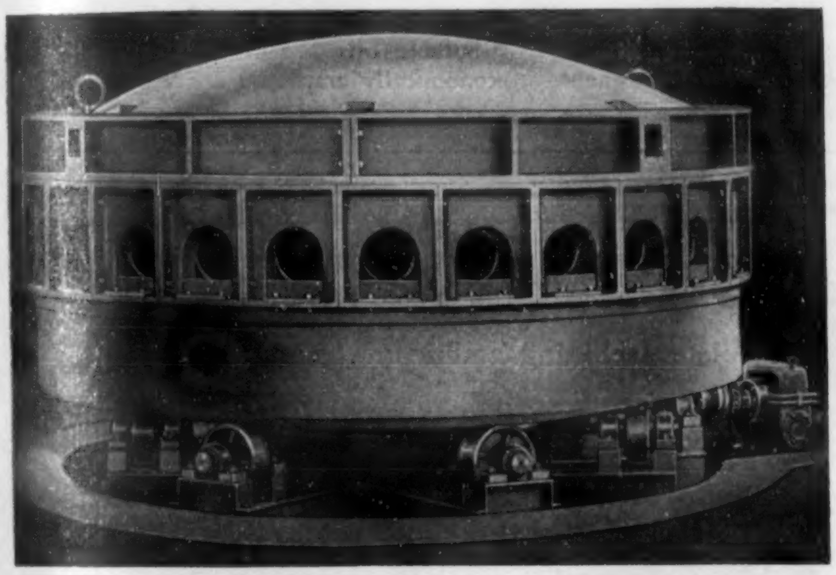

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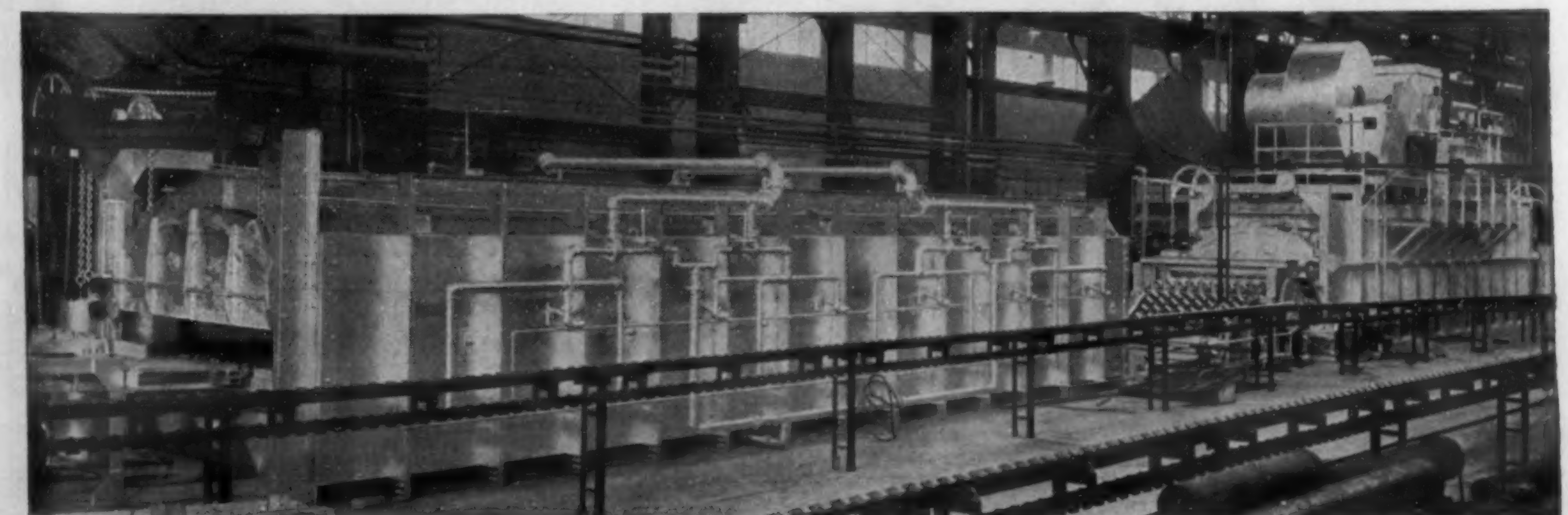

curs within the scale itself and causes buckling to take place while the base layer is still cold and brittle. Sometimes, however, heavy scales must be heated clear through so that they expand in relation to the cold base metal.

Equipment is now available which accomplishes the required high-heat transfer by two special features. First is a specially designed flame-jet assembly which increases flame-jet velocities, 50-70 per cent above those normally used in welding. Other is a specially designed burner heat which preheats the gases prior to their reaching the flame port or point of actual ignition, resulting in a higher flame temperature than ordinarily. Special variations of the general design have been developed for specific applications.

Examples are tooth-brush-type heads for short pipe and casting interiors; ramrod type interior of long pipes; and 3-sided U-shaped heads for descaling blooms and billets completely in 2 passes instead of the usual single pass per side. For some work, wheels have been added to the descaling equipment. For all types, special skids are provided to prevent damage to the equipment and to maintain the flame at the proper distance from the work.

Automatic descaling machines appear to be satisfactory for descaling blooms, billets, and heat-treated bars and pipe. For such work, the material is continuously fed on roll tables to the descaling set-up. Equipment is mounted on a floating frame that follows the camber of the work moving through it. Details of some specific applications of flame descaling show the advantages of the method. In a few operations, combination flame descaling and pickling overcome minor shortcomings of both processes.

Many alloy steels which resist descaling action of both flame and pickle can be quickly and effectively descaled by a combination process in which flames loosen the scale sufficiently to allow the acid to penetrate. This has enabled one plant to reduce pickling time for some steels from 10 hrs. to less than 1 hr. Flame descaling is being used to supplement sand-blasting for removing weld scale and excess flux from electric arc welds.

—E. W. Deck, *Steel,* Vol. 110, June 1, 1942, pp. 81-84; June 8, 1942, pp. 86, 88, 115.

Oils for Blackened Steel

Condensed from "Metal Finishing"

Oil films are extensively employed over phosphatic and oxide coatings on steel for supplemental protection. In such applications the protective value of the coating is of a relatively low order compared to that afforded by the oil film. The protective value of the coating plus oil film exceeds in magnitude the sum of the protection obtained by the coating and oil film when applied individually to the same steel.

In this research, comparative salt spray data were obtained on the protective value of various oils, using steel panels uniformly coated with black oxide. The panels were cleaned and treated in "Jetal" baths, dried, and coated with the oil to be tested.

Results are reported on 19 oils of four types as follows: (1) Straight mineral oil (2) fatty acid type oils (3) anti-rust compounds of the stoddard solvent type (4) water soluble oils. The water soluble oils were employed as water emulsions at 180 deg. F., using 50 per cent oil by volume in the mixtures. Sample panels after oiling were allowed to drain and dry either 24 hrs. or over night.

The results in general showed mineral oils to be least effective and the better soluble oils to be most effective. A straight mineral oil gave slight rust in 2 hrs., different solvent anti-rust types in from 18 to 42 hrs., and soluble oils in from 37.5 to 300 hrs. The latter type of oil possesses other advantages. The film produced may be widely varied by varying the proportions of oil and water in the mixture, though the thinner coatings obtained from the more dilute emulsions give less protection.

There is no fire hazard with these oils. The work may be transferred directly from the last rinse to the hot emulsion. The hot emulsion may also be applied by spraying. Dragout losses are less costly because of the high percentage of water in the mixtures. The soluble oils generally cost less than the other types. The films obtained with this type of oil may be either oily or mildly greasy.

Soluble oils are being successfully and economically employed for protecting vari-


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ous oxide coated parts during assembly, inspection, and storage. They are being used very satisfactorily for permanent protection of oxide coated parts or enclosed assemblies of instruments and dial gages. In certain cases they are applied without dilution as slushing compounds.

—E. A. Parker and A. K. Graham, *Metal Finishing,* Vol. 40, July 1942, pp. 363-367.

Protection of Steel by Cast Iron Borings During Heat Treatment

Condensed from "The Iron Age"

A series of experiments was conducted on steels in the range from Armco iron to 1 per cent C steel. The steels analyzed from 0.01-1.04 C, 0.017-0.30 Mn, 0.025-0.040 S, and 0.005-0.020 per cent P.

Cast iron borings were obtained from gray iron machine castings, machined dry. Soda ash was mixed with the borings. Thirty cans were heated for 6 hrs. and cooled to room temperature. The maximum surface carbon was estimated by comparison with standard samples.

The results obtained after heating for 6 hrs. at 1450 deg. F. showed slight decarburization of 1.04 per cent C, but 0.65 and 0.40 per cent C steel was unaltered. When soda ash was added, the latter were carburized to about 0.80 per cent C while 1.04 per cent C remained the same.

At 1550 deg. F. the activity of plain borings and steel surfaces was increased. Very-low-carbon material was not affected by plain borings, while the 0.17 per cent C steel was carburized. The 0.40 per cent C steel seemed to be in equilibrium at this temperature.

The addition of soda ash energizes the reaction and causes carburization in the lower-carbon steels. Higher carbon steels are more generally carburized in the upper range of soda ash concentrations.

The results obtained at 1550 deg. F. are practically duplicated at 1650 deg. F. At 1750 deg. F. Armco iron gave a value lower than the value obtained at lower temperatures. The 0.17 per cent C steel also showed slightly decreased activity in the same direction.

—David L. Ellis & Joseph F. Oesterle, *Iron Age,* Vol. 150, July 30, 1942, pp. 45-49.

Flame Hardening

Condensed from "Mechanical Engineering"

To obtain uniform high-quality flame-hardened parts the process must be given the same rigid technical control as in other heat-treatment forms. It is not an easy cure-all and is a new technical process.

Spot hardening, the most elementary, consists of holding an oxyacetylene flame, or flames, over an area for a fixed period, then quenching. Spin hardening is done by a torch, or torches, around the peripheral surface of a part of cylindrical design. The part is revolved 1000 surface in. per min. while flames are applied. Then parts are removed from the mandrel and quenched.

Progressive flame hardening may be applied to either flat or cylindrical parts. The quench follows ⅜ in. back of the last row of flames, the quench medium being air, soluble oil or water.

Spiral progressive flame hardening is applied to shafts 2 in. or larger in diam. It is rotated at a peripheral speed of 4 to 6 in. per min. A quench follows ⅜ in. behind the flame. The burner is advanced the exact width of the flames each work revolution.

Combination of spinning and progressive welding can be used on long cylindrical shafts. The burners are allowed to dwell for a time, then moved longitudinally along the work surface. A circular quench head follows the burners. A very uniform hard case is produced.

Temperature control is a very critical factor in obtaining high-quality results. But since the temperature can't be measured directly, other factors must be weighed carefully, such as type of equipment, oxygen and acetylene pressure, distance between burner tip and work, the time interval, and design of the parts hardened.

To properly interpret results the microscope is best, comparing standard specimens with the work just completed.

The facts in this article were derived from experiences of the author in the R. K. Leblond Machine Tool Co., Cincinnati, where he is metallurgist.

Gears ranging from 4 diametral pitch to 1 diametral pitch are the most universal parts hardened by the progressive flame-hardening method. Two gears are set tightly together and two special gear-hardening burners are applied simultaneously. Thus the hardening time can be greatly re-

duced over hardening a single gear with one burner. A flush quench is automatically applied when the flames are extinguished, thus insuring complete hardness of the rounded end of the gear tooth which is subject to clash condition.

One application is for hardening some large cast-steel, crankshaft-lathe-tool bars on four sides by the progressive method. Some of the advantages over carburizing are: Number of operations reduced 36 per cent, material cost lowered $20 per ton, distortion reduced 85 per cent, slightly higher case hardness is obtained, in large bars it was possible to change from a solid forging to a cored steel casting, reducing weight 35 per cent.

A large ring gear is a typical example of a part which would be almost impossible to harden by any method other than progressive flame hardening. It has a bore of 16 in. and is 24 in. in outside diameter. The operation in no way increased the runout of the part and resulted in a shrinking of only 0.001 to 0.002 in. in the bore. More than 100 different jobs in the Leblond plant are now routed to the progressive flame-hardening machine and more than 9000 parts have been hardened to date.

Strains are of course set up by flame-hardening. Stresses between the soft base metal and the flame-hardened surfaces are approximately 16,000 lbs. per sq. in. for chromium-molybdenum cast iron and 30,000 lbs. per sq. in. for SAE 3140 or 4140 steel. Stresses can be reduced 40-50 per cent by stress-relieving the part at 400 deg. F. for a moderate time. Stresses are actually less than between core and case of carburized and hardened steel.

Though the Leblond company has flame-hardened some 44,000 parts and has 235 different jobs routed to the flame-hardening department, the process is still in its infancy.

—A. L. Hartley, *Mechanical Engineering*, Vol. 64, July 1942, pp. 531-540.

Rust Protection

Condensed from "Sheet Metal Industries"

After a brief discussion of commonly encountered conditions in atmospheric corrosion, artificially applied coatings are considered. Nickel plating has been widely used to protect steel. Commercially, porosity tends to disappear only with thicknesses over about 0.0020 in., although 0.0006 in. is usually considered adequate for mild service and 0.0007 to 0.0010 in. for outdoor service. Porosity can be decreased by careful filtering of the nickel plating solution.

Since nickel tarnishes, a chromium overplate is frequently used. Even the thinnest chromium deposit is extremely effective when used over nickel. Copper undercoats to nickel do not cause a marked increase in corrosion resistance for the thicknesses usually used. Undercoats of zinc for nickel are used commercially because the zinc anodically protects the steel exposed by the pinholes in the nickel; however, special nickel plating solutions must be used and it is a moot point whether these composite coatings are superior to nickel coatings of equal total thickness. Bronze plating provides moderate protection under indoor conditions but is of little value for outdoor exposure; it is useful as an undercoat for nickel.

Electrodeposited tin coatings are increasing in importance because thinner coatings can be used than are possible with hot dipped tin coatings and because tin is one of the few coatings that can be safely allowed to come into contact with modern high explosives. Tin, however, does not withstand atmospheric corrosion as well as zinc or cadmium deposits of equal thickness, although it is preferable as a basis for soldering. An electrodeposited tin coating is very liable to stain unless it is protected with an application of lanoline in white spirit or by passivating in a suitable solution, used at 85 C for an immersion time of 5 min.—(mentioned is one with 40 g. per liter Na_3PO_4, 20 g. per liter sodium dichromate, 14 g. per liter NaOH and 5cc of Perminal KB used at 12.5 pH.)

Zinc and cadmium are undesirable for use in electrical assemblies, or in contact with high rubber containing sulphur as the result of their sensitivity to acids. Cadmium has been preferred to zinc in the past in spite of its comparatively high cost because of its better appearance; however, zinc often would have been equally satisfactory.

Some investigators have claimed that Zn-Cd alloy deposits with under 10% of either metal are superior in corrosion re-

sistance to either zinc or cadmium deposits. Corronizing consists of a composite deposit in which zinc or tin is deposited on an undercoating of nickel and the whole heat treated; thicknesses of nickel and zinc are very small. This process has been used fairly extensively in the United States.

—H. Silman, *Sheet Metal Ind.*, Vol. 16, July, 1942, pp. 997-1008.

A New Substitute Finish

Condensed from "Products Finishing"

Priorities restrictions have made many plated finishes unavailable. The "vitreous silver" finish described here was developed as a substitute for these unavailable finishes.

Since the basis metal most likely to be available is steel, and the most practicable finish metal not under priorities restrictions is silver, a silver-finished steel was chosen for investigation. The problems to overcome with this finish are how to protect the silver from tarnish and how to make it resistant to fairly severe handling. Lacquer finishes are not satisfactory from the standpoint of abrasion resistance and availability. A ceramic glass finish was proposed and tried.

A ceramic jewelry enamel was developed that had sufficient scratch resistance and resistance to thermal and mechanical shock. The adhesion to the ordinary cyanide-silver deposit was not satisfactory, but it was found that adhesion to the slightly granular silver deposit from the Woods type of bath was good.

Ordinary cleaning and plating procedures are used. The strike bath has the formula:

Silver nitrate.....0.15 to 0.30 oz. per gal.
Sodium cyanide......10 to 20 oz. per gal.
Potassium nitrate.....0 to 10 oz. per gal.
Current density..10 to 25 amps. per sq. ft.
Time—1 to 3 min.

The plating bath formula is:

Silver nitrate ....4 oz. per gal.
Sodium cyanide ....4.5 oz. per gal.
Potassium nitrate.........16 oz. per gal.
Current density...3 to 6 amps. per sq. ft.
Temp.—80 to 85°F.; Time—20 min.

After rinsing and drying the article, a water solution of the jewelry enamel is applied with a spray gun and the enamel fired at 1450 to 1500 deg. F. for 5 min.

The finish is lustrous and attractive and has exceptional resistance to heat, water, mild alkalis and acids. It will not, however, withstand bending.

—Harold J. Kroesche, *Products Finishing*, Vol. 6, July 1942, pp. 30-34.

Coated Welding Electrodes

Condensed from "Wire & Wire Products"

Welds made with mild steel bare rods will have a tensile strength only about 80% that of the wire, while elongation will be about 6% because the weld is full of oxides and nitrides. The first purpose of a coating, therefore, is to protect the metal passing across the arc from oxygen and nitrogen by means of the heavy inert gases produced by combustion of the materials comprising the coating.

The use of coated welding electrodes began to spread rapidly a little more than a decade ago. The wire for mild steel electrodes may be of the same analysis as used in the old bare rods, but the strength of the deposit will be 65,000 to 85,000 lbs./sq. in. as compared to about 45,000 lbs. for deposits of bare rods. The coating must enable welder to use considerably higher current than with bare rods, must provide average of 3 times the welding speed of bare rods, increase the ductility by 400% without depositing any strengthening alloys (except possibly to replace some of the manganese and carbon otherwise burned away).

There is no universal coating. Coatings must be specially designed for the type of rod (stainless, hard surfacing, etc.) and for the use (D. C., A. C., high speed flat position, all position, etc.). Coatings are composed of a number of chemicals and minerals, each of which has a specific action . . . one may protect crater against oxygen, another may give smoother operating characteristics, eliminate spatter, etc. Each rod manufacturer's coating differs from that of every other, even for the same type rod. Formulae are kept secret, and, of course, there are countless combinations.

Almost all heavy coated rods in the United States are extruded; coatings are applied in somewhat plastic form under tremendous pressure. The rods are passed through die holes and further processed

(including precise and controlled drying). Texture of coating must be dense. There must also be no materials in coating which might pick up moisture from the air. Undercutting, undue spattering, and erratic arc are all due to improper coating.

However, rods of different make but the same type also differ because one manufacturer may sacrifice a specific property for another. As the result of rigid manufacturers' tests, all rods on the market are of acceptable quality. However, there are certain small points of technique in which these rods of different make may differ; unless these are given due consideration by the welder, he will have trouble or not get the results he could otherwise. Heavy protected coatings have proven the most important development in the welding industry. Acceptance of electric welding in shipbuilding, tanks, and other ordnance work is due entirely to this development.

—R. O. Waldman, *Wire & Wire Prod.*, Vol. 17, Aug. 1942, pp. 398-399; 425.

Gas Welding Cast Iron

Condensed from "The Iron Age"

Successful gas welding of cast iron demands the ability to identify the type of iron in the part to be welded so that it may be properly heated and cooled to maintain those properties after welding.

White cast iron must be preheated to from 600 to 1300 deg. F., depending upon the size and shape of the casting and the location of the break. If the weld is so located that there is freedom for expansion, lower temperature will be sufficient; otherwise higher temperatures must be used. Oxweld No. 9 cast iron and Oxweld ferro-flux are satisfactory rods and flux. After welding, work should be heated uniformly to about 1600 deg. F. and allowed to cool in the open air.

Gray cast iron welding follows the same procedure except that local preheating may be used if the part is sufficiently isolated from the main part of the casting to permit free expansion and contraction. After welding, the casting should be reheated to 1300 deg. F. and cooled in confined atmosphere.

Alloy cast irons should be preheated the same as other castings. After welding they require special heat treatment. Alloy welding rods are used.

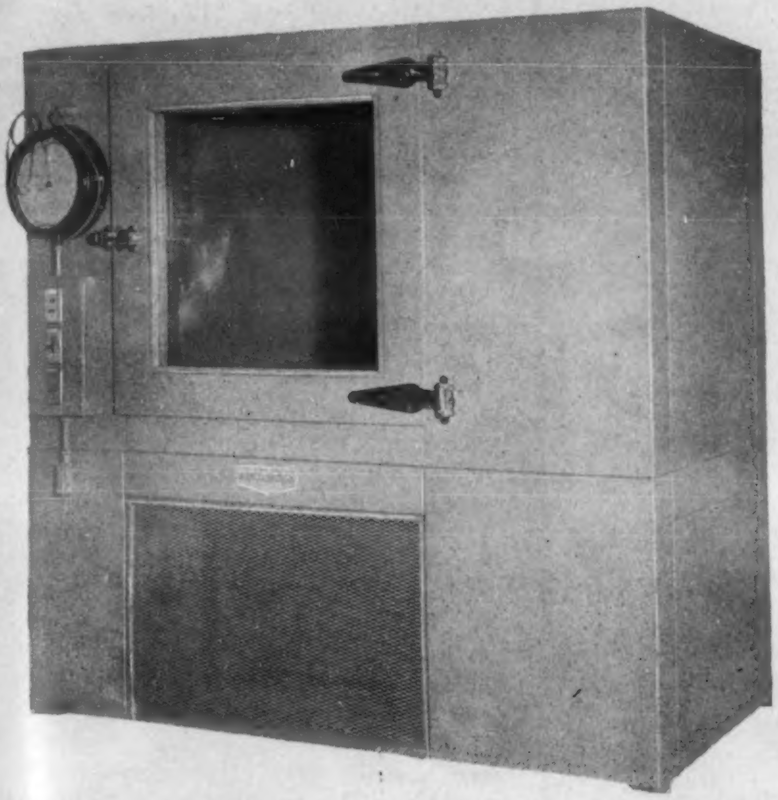
Poisoned cast iron, impregnated with foreign substances, are difficult to weld. Control of molten metal is important, because molten cast iron is extremely fluid and tends to remain fluid for a long time. The pieces should be placed parallel to and touching each other. The welding head should be a size larger than that used for steel and the flame should be neutral. To tack weld the rods in position, the tip of the inner flame may be played in the valley between the rod until the metal melts and the two fuse together. A third rod used as filler should be dipped in a flux.

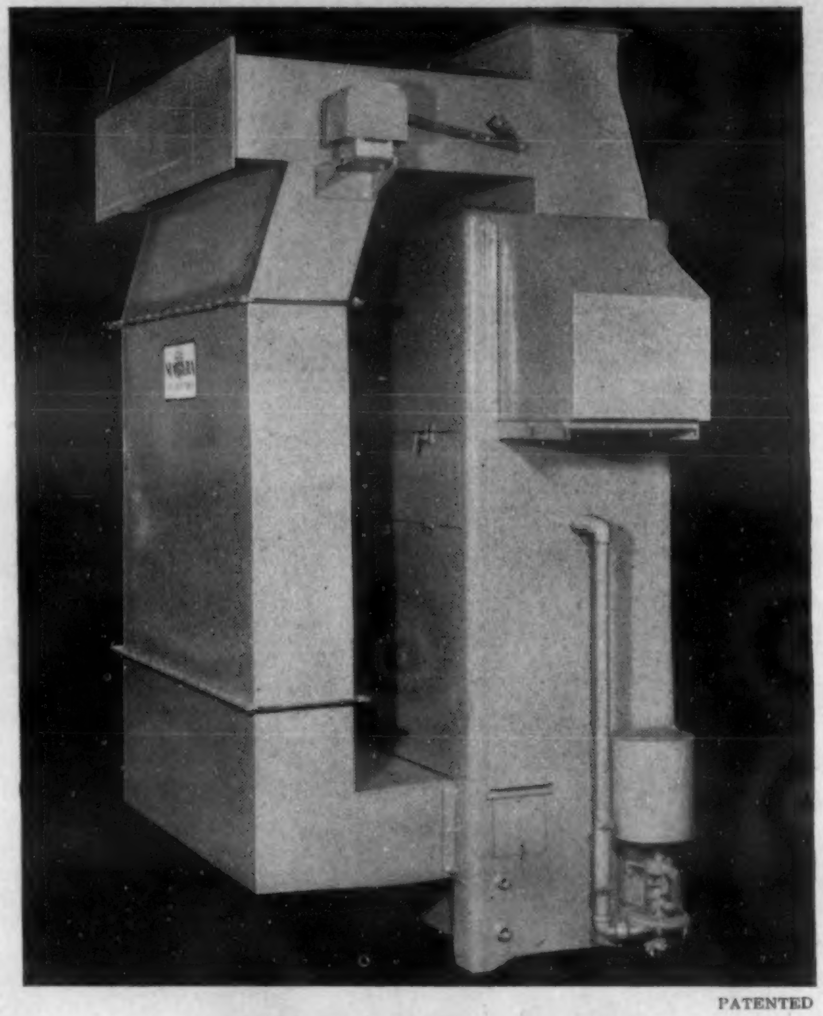
The end of the pieces to be welded should be heated for an inch or two, letting the inner cone touch the metal, moving it in a circular motion so that both sides are heated evenly. As the metal gets hot, the circles are narrowed. The rod is slowly brought closer, timing the movements so that the welding rod and base metal will reach the melting point at the same time. When this point is reached, the welding rod is lowered into the melted base metal and 1/4 in. of it melted off. Molten metal should not be stirred with the welding rod. The end of the rod should touch the base metal and melt off. When white spots are noticed on the surface, the flux should be added. After tack welding, the pieces should be heated with a blowpipe to about 300 deg. F.

A typical example of welding a heavy casting is a gear case about 2 1/2 ft. long, cracked upward from the opening. It was preheated to 500 or 600 deg. F. in a furnace heated with charcoal. Bricks for the furnace were laid on the cement floor and the sand spread over them. Walls were built of a course of brick. The crack was chipped out to form a 90-deg. V. The charcoal was ignited by a blowpipe and welding was started at the far end of the left-hand branch of the Y-shaped crack. Asbestos was placed on the edge of the furnace to protect the operator from the heat.

After the welding fire was left to burn itself out the casting was not disturbed until completely cold. If the casting is too large to be moved to a welding shop, a preheating furnace is built around it.

—*Iron Age*, Vol. 150, Aug. 6, 1942, pp. 58-62.





Design and Applications

3

METALS, ALLOYS, METAL FORMS
ENGINEERING DESIGN, METAL SELECTION

Physical and Mechanical Properties (including Fatigue and Creep) • Corrosion and Wear • Engineering Design of Metal-incorporating Products • Selection of Metals and of Metal-Forms • Competition of Metals with Non-Metals • Specific Applications of Metals and Alloys

CONTENTS

Sprayed Metal Bearings

Condensed from "The Iron Age"

Spraying bearings, bushings and liners consists of using predetermined amounts of metal on an arbor which is 0.001 to 0.003 in. under finish size. The o.d. is then machined, and since only partial bond is formed, the bushing may be pressed off. When immersed in oil bearings absorb about 10 per cent of their weight. Spraying permits the combination of various metals which could not conveniently be combined either by casting or powder metallurgy.

Comparison of cast with sprayed babbitt shows that latter has a coefficient of friction about 25 per cent lower than the former at a speed of 1,000 ft. per min. Sprayed babbitt seizes at 7040 lbs. per sq. in. as compared with 5760 lbs. per sq. in. for cast. Cadmium-silver-copper tested had a higher seizure load than cast lead-bronze, and lower coefficient of friction.

A series of tests were made on a new type of bearing designed to have anti-friction qualities of a tin-base metal in combination with other desirable components. The surface was covered with fine pores. Into these a tin or tin-base metal was loaded. The results of the tests showed a coefficient of friction which was but a fraction of either lead bronze or cadmium-silver.

To test the strength of sleeve bearings, three sprayed metal bushings were used (1) was Metcoloy No. 1, stainless steel; (2) silicon-aluminum; (3) Sprabronze; and also (4) another of pressed powdered bronze. Bushings were placed in a compression testing machine, between fitted plungers, and compressed to failure. Nos. 1 and 3 failed by splitting at end while Nos. 2 and 4 failed by bulging. Results showed that all had sufficient strength and that the poorest sprayed bushing had more than twice the compressive strength of powdered metal bushings:

	No. 1	No. 2	No. 3	No. 4
Elas. lim., lbs./in.^{2}	44,000	25,050	19,140	7,500
Load in lbs./in.^{2} required for set of 0.002 in.	53,100	26,670	21,350	8,125
Ult. str., compression lbs./in.^{2}	70,850	53,100	30,600	15,100

—*Iron Age*, Vol. 149, June 25, 1942, pp. 52-53.

New Electrical Contact Materials

Condensed from "Electrical Review"

Silver and platinum are used as contact materials in telephone relays. They differ chiefly in their tendency to form tarnish films in industrial atmospheres. For heavier currents than those used in telephone work, platinum is unsuitable, partly because of the high cost of the larger contacts needed and partly because of its poor resistance to the destructive effects of arcing.

Silver has been used in many cases with success, but under particularly severe conditions in a.c. circuits, such contacts fail by welding at "make," while in d.c. circuits they suffer from "material transfer." For this kind of duty, tungsten contacts have been used, as they have little tendency to weld and much greater resistance to material transfer. However, in apparatus where only very moderate spring pres-

sures are available, the tungsten oxide film produced by arcing is very tough and often leads to inadmissible degrees of contact resistance.

Certain of the silver-molybdenum and silver-tungsten powdered metal combinations have proved to be satisfactory, but they are primarily for use where far greater mechanical pressures between the contacts are available to off-set the increased contact resistance as compared with silver. They are not ductile, so that the contacts are relatively expensive to make.

A new silver-nickel material provides a compromise between ability to withstand the destructive effects of arcing and the liability to material transfer on the one hand, and reasonably constant contact resistance under fairly light spring pressures on the other. Its cost is not disproportionate to that of silver, and it is ductile.

Microscopic examination shows finely dispersed nickel particles in a silver matrix. The nickel is responsible for relative freedom from sticking and resistance to wear and arcing. The annealed hardness of silver-nickel is greater than that of silver, while its conductivity appreciably exceeds that of tungsten.

Determination of comparative tendencies to material transfer from negative contact of various metals and alloys after 400,000 operations at 110 volts rectified d.c. indicates that transfer of silver-nickel begins at a lower current than with tungsten, but the slope of the curve is far more gradual.

When current exceeds about 2.1 amps. in the circuit-conditions employed, tungsten is transferred at a greater rate than silver-nickel. Under service conditions in heavy-duty relays, contact resistance of silver-nickel approaches that of silver.

Satisfactory life periods have been obtained when handling 8-10 amps. in 250-volt a.c. circuits and 3-4 amps. in d.c. circuits of low inductance. In the latter instance, a spark quench in the form of a selenium rectifier was used. These current values would probably be reduced under highly inductive conditions, or if no spark quench were included.

Experimental work indicates that the order of decreasing freedom from sticking of various contact materials is tungsten, silver-tungsten, silver-molybdenum, silver-nickel, 10 per cent gold-silver, silver, 60 per cent palladium-copper, platinum-gold-silver, palladium, commercial platinum, and 20 per cent iridium-platinum.

—H. R. Brooker, *Electrical Rev.*, Vol. 130, May 22, 1942, pp. 651-652.

Heat Resistant Alloys

Condensed from "Metals Technology"

Cast 26 Cr, 12% Ni alloys are austenitic, but carbides, ferrite, sigma (a lamellar aggregate), and non metallic inclusions may be present. At elevated temperatures, ferrite is weak, but ductile and not necessarily detrimental.

Sigma may develop readily near 1600 deg. F. if chromium and silicon are high in comparison to nickel. Although sigma is weak and brittle, small amounts may cause no more embrittlement than carbide precipitation. A limitation of ferrite content above 1800 deg. F. may also restrict occurrence of sigma at 1600 deg. F. if unusual sigma stabilizers such as molybdenum are not present. The non-

magnetic lamellar constituent appears to be associated with high nitrogen (around 0.2%). L. C. S. at 1800 deg. F. (limiting creep stress which will produce uniform elongation rate—stage II—of 1% in 10,000 hrs. as extrapolated from tests under 2000 hrs. duration) increases linearly with the percentage of carbon from 600 lbs./sq. in. for 0.19% C to a maximum of 2,650 lbs./sq. in. for 0.52% C, then decreases with the appearance of continuous carbide networks.

Nickel, nitrogen, and carbon tend to increase strength at temperature, while chromium, silicon, tungsten or molybdenum increase ductility at the expense of strength if they do not lead to excessive sigma. L. C. S. at 1800 deg. F. may vary from 830 to 2200 lbs./sq. in. and life in a rupture test at 1400 deg. F. under 20,000 lbs./sq. in. from 11.6 to 25.4 hrs. for analyses representing the extremes of a narrow chemical composition of 26 Cr-12% Ni; therefore, restrictions of chemical composition alone are not adequate for controlling elevated temperature strength.

Strength and ductility at elevated temperature are inverse qualities and a choice should be made between them based on service analysis. However, ductility values are considerably affected by the technique of measurement. Total elongation at fracture under constant load and temperature appears to be the best rapid measure of comparative ductility. Since brittle failures sometimes occur at room temperature after extended elevated temperature operation, residual ductility is a desirable characteristic. Tensile tests after brief aging (i.e. 24 hrs. at 1400 deg. F.) give a useful indication of this property.

Samples showing an elongation in a room temperature tensile test of 4.3-28.3% in 2 in. after such an aging showed a corresponding elongation of 1.5-24.0% in 2 in. in elevated temperature rupture tests at 1400 deg. F. under 20,000 lbs./sq. in.; however, the L. C. S. at 1800 deg. F. for these alloys varied from 3000 for the more easily embrittled alloy to about 1,200 lbs./sq. in. for the most ductile alloy. The residual ductility at room temperature decreases with increasing load for approximately constant time at 1800 deg. F. and also with increasing time under constant load. Therefore, specification of high elongation after aging is not a reliable index of residual ductility after exposure to stress at high temperature.

Structural damage as distinguished from embrittlement by precipitation hardening may be the cause of low residual ductility or of failure. The specification of a minimum elongation at room temperature places a premium upon weaker alloys if used alone, but is valuable to indicate tendency toward embrittlement, carbide precipitation and presence of serious inclusions. Strong alloys are more susceptible to failure under overloading from hindered thermal contraction than are very ductile compositions. Sstress strain rupture tests provide a measure of elevated temperature strength, ductility and life before fracture under overload. Such a test might be included in a specification for alloys for elevated temperature service if it did not require a precision confined mainly to creep laboratory practice and if magnetic analysis were not more promising.

The amount of ferrite developed with or without stress at elevated temperatures is an inverse function of creep strength; permeability (H-24) varied from 2.01 to 1.02 after a water quench from a 24-hr. soak at 2000 deg. F. while L.C.S. at 1800 deg. F. for the same alloys varied from 600 to 2,200 lbs./sq. in. Such a magnetic test would have many advantages over a creep test requirement and would also eliminate heats with excessive amounts of ferrite which might transform to sigma during service.

—H. S. Avery, E. Cook and J. A. Fellows, *Metals Tech.*, Aug. 1942, T. P. 1480 (22 pp.)

Nitrided Cast Iron as a Substitute

Condensed from "Metallurgia"

All drop forgers and stampers are familiar with "clipping tools," used in a press adjacent to the stamp to remove the "flash" of metal that is forced out between the two dies as surplus.

Nitrided cast iron was found in actual service to be the most effective material. Thus, 28-28 Ni-Cr steel tools produced an average of 3,600 clippings per tool; gray cast iron, 4,200; typical chrome H. R. steel, 9,000 and nitrided cast iron, 30,000.

It was natural to consider possibilities of nitrided cast iron. Nitrided surfaces

offer heat-resistance, strength and hardness. Casting the iron to close to finished shape seemed practical.

A pair of tools was cast to pattern in the proper quality cast iron. Outside dimentions were cast to size, but working faces were left 1/8 in. full to allow for machining. Castings proved of close texture and so free from blowholes that, prior to nitriding, the polished working faces resembled steel. These faces, when rough machined, were left 1/32 in. full so that any areas decarburized during preliminary heat-treatment could be removed prior to hardening in nitrogen.

After rough machining, the tools were heated slowly to 1652 deg. F., soaked for a few minutes, then cooled in a weak air blast. Since this special iron had air-hardening properties, this treatment strengthened it to support later the hard face and also made it receptive to the penetration of nitrogen.

In finish machining, a slight radius was shaped on all sharp corners to reduce risk of spalling through penetration from two directions.

The tools were included with a batch of steel parts in the nitrogen hardening. They were treated 90 hrs. at 932-950 deg. F. On withdrawal they closely resembled treated steel parts.

In service the tools were extremely successful. Clippings were clean and seizures few. Temperatures of working had no effect on the nitrided surface hardness. Though too hard to file, the absence of distortion during production plus the infinitely longer life offered made it almost unnecessary for any touching-up during use.

—Bernard Thomas, *Metallurgia*, Vol. 26, July 1942, pp. 87-88.

Thermit—Industrial and War Uses

Condensed from
"Chemical & Metallurgical Engineering"

Thermit is an important ingredient of the all-too-familiar incendiary bomb and chief material in the thermit welding process, a high temperature operation, applicable to heavy work such as crankshafts, stern frames of ships and machine parts. The process is in the field of aluminothermics and its use for many new applications awaits only the opportunities to explore and perfect them.

In welding it is applied both to repairs and new construction work. It is utilized to produce carbide-free metals and alloys. Thermit is used alone or as a priming charge in incendiaries.

The science of alumino-thermics is based on aluminum's great affinity for oxygen. An initial temperature of 2100 deg. F. is needed to start the reaction, whereupon the granular aluminum burns in the oxygen supplied by the metallic oxide until consumed, leaving a molten slag of aluminum oxide over a bath of superheated molfen metal. Resulting temperature is over 5000 deg. F.

An oxidizing ignition powder, such as barium peroxide, is ignited with a match, fuse, fulminate cap, or black or smokeless powder, the reaction taking 30 sec.

The magnesium-thermit incendiary bomb was invented during the closing months of World War I. Common sizes of pres-

ent Axis bombs weigh 2.2 lbs. The bomb is a tube of magnesium alloy filled with firmly packed thermit mixture, fitted with tail fins and a firing mechanism.

The bomb ignites on impact, a pin being driven into a firing cap that sets fire to a starting charge, which ignites the thermit. It normally burns for 15 min., but water speeds it to 2 min.

Some bombs contain oil of high flash point along with thermit, with metallic sodium or potassium sometimes mixed with the oil. Japan uses thermit alone as a burning mixture. The thermit even burns under water. Peculiarly, thermit burns through a 1-in. steel plate faster than through a plank, the charcoal on the plank serving as insulator.

Thermit, as employed for welding, is a mechanical mixture of finely divided aluminum and iron oxide in the form of magnetic iron scale, proportioned 3 lbs. of iron scale to 1 lb. of aluminum.

Actual thermit mixtures for welding contain materials other than aluminum and iron oxide. Size of the particles of the metallic oxide influence the time and temperature of the reaction. Through the addition of metallic elements, a wide variation in the analyses of thermit-made-steels is provided. By the same means tensile strength, ductility and hardness of the resultant steel are controlled.

The average analysis of thermit steel for welding is: Carbon, 0.20-0.30 per cent; manganese, 0.50-0.60; silicon, 0.25-0.30; sulphur, 0.03-0.04; phosphorus, 0.03-0.04; aluminum, 0.07-0.18.

Such a weld has an average tensile strength of around 70,000 lbs. per sq. in., with an elastic limit of around 36,000 lbs.; it has properties approaching forged steel.

Four common thermits for ferrous metals are: *Plain,* finely divided aluminum and iron oxide; *forging,* which contains additions of manganese steel and mild steel punchings, used on forged steel; *cast-iron,* with additions of ferro-silicon and mild steel punchings, used for cast iron; and *Wabbler thermit,* for building up worn wabbler ends for rolls and pinions in steel mills.

There are two welding methods: Pressure and fusion, the latter more common and where the thermit steel is deposited as weld metal. In the latter, parts are lined up and a parallel-sided gap, at the point where the weld is to be made, is cut, the width of the gap depending on the size of the section. Around the gap a wax pattern is formed and a refractory sand mold built, which provides an annular space at the weld.

Parts to be heated are preheated to burn out the wax of the old pattern and dry the mold. Thermit is placed in a specially designed crucible. When reaction is completed, crucible is tapped, thermit steel running into the mold. This steel, having 100 per cent superheat, held in place by the mold, gives up its superheat to adjoining parts and fuses with them.

In rail welding, molds are made on standard patterns and wax patterns are dispensed with.

—J. H. Deppler, *Chem. & Met. Eng.* Vol. 49, July 1942, pp. 93-96.

Metal-Design of a Japanese Aircraft Engine

Condensed from "The SAE Journal"

The results of a study of an engine taken from a crashed Japanese plane are of considerable metallurgical interest. At the time when this engine was built, there were evidently adequate supplies of nickel, cadmium, chromium, cobalt, copper, molybdenum and tungsten. The single magnesium alloy found contains 4.6 Al, 2.6 Zn and 0.28 per cent Mn, in addition to magnesium.

With regard to aluminum alloys, 17 S is used for many parts, such as main crank case, tappet guides, and piston-pins. An alloy containing 3.93 Cu, 1.37 Mg and 1.67 per cent Ni, either cast or forged, is used for special purposes such as pistons, cylinder heads and supercharger front housing.

An all-purpose steel, either case-hardened or hardened throughout, is used for connecting-rods, crank-shaft, valve rockers, etc. The crank-pin contained about 1.5 Cr, 3.5-4.5 Ni, 0.3-0.4 Mo, 0.35-0.5 per cent Mn, and small amounts of silicon and copper as impurities. Carbon is varied as required. The same steel with lower molybdenum and 0.5-0.9 W and 0.2-0.4 per cent Co added is used for the propeller-shaft and the starter and accessory drive-shaft.

Carburizing 4.5 per cent Ni steel with about 0.8 per cent Cr is used for propeller reduction gears, cam, and knuckle pins. This steel with 0.4 per cent Mo added is used for the reduction-gear pinions.

Nitriding is used only in the cylinder barrel, the steel conforming very closely to AMS6470. The depth of nitriding is 0.10 and 0.20 in. in the 2 barrels cut. Core hardness is 22-34 Rockwell "C" in one specimen. Magnetic inspection of the steel parts showed acceptable material.

Plating is used extensively. Supercharger oil-seal rings and most of the propeller-shaft were cadmium-plated, as were the more common points such as valve springs, valve rockers, push-rods and impeller shaft. Chromium plate is used on the under side of the inlet-valve head and on upper piston-compression-ring outside diameters. Lead is used in the master-rod bearing bore.

—W. G. Ovens, *S.A.E. Journal*, Vol. 50, July 1942, Trans. pp. 253-266.

Selecting Alloy Steels

Condensed from "Metal Progess"

A practical guide has been set up to show the trends of influence of certain alloying elements when added to a plain carbon steel, such as 1015, 1020, or 1030. The proposed scheme applies only to fine grained steels.

In the chart or table, the rating numbers vary from zero to +10 where the element is favorable and from zero to — 10 where use of the element is detrimental. P means that the effect is proportional to the amount of the alloy. S means small quantities

Effect of Alloy Elements on Properties of Steels

	C 0.1-0.3%	C 0.3-0.85%	Mn 0.25-2%	P —0.15%	S —0.3%	Si —2%	Cr —1.1%	Ni —5%	Mo —0.75%	V —0.25%	Cu —1.[illegible]%
ANNEALING: Degree of accuracy necessary to control temperature when annealing to lamellar pearlite—	+3L	+5P	—2L	0	0	—2P	+3P	—5P	—3L	+2P	—(?)
CARBURIZING: Depth of case only—	0	—4P	+5P	0	0	—10L	+2P	—3P	—2P	+2P	—10L
CORROSION: In atmosphere or weakly corrosive liquids—	—3P	—6P	0	+10P	—10P	+2P	0	+6L	+2P	0	+10S
CREEP RESISTANCE: At temperatures up to 950° F.—Steels drawn at higher temperatures—	+2I	—3P	0	0	0	0	+1P	0	+10P	?	?
DISTORTION ON OIL QUENCHING and susceptibility to quench cracks—	—1P	—2P	—4P	—3P	0	—1P	—4P	—2P	—3P	—1I	0
FABRICATION IN COLD BENDING—	—2L	—10P	+2I	—10L	—7P	—6P	—10P	+5S	+3S	+3P	+2P
HOT WORKABILITY—formation of seams, scale, decarburized skin, resistance to flow—	+2P	—7P	+7S	0	—10S	—5P	0	—6P	—3P	0	—10S
HARDENABILITY or hardness penetration (basis 0.7-1.0% Mn)—	+1P	+2P	+10P	+3P	—2P	+2S	+7S	+10L	+7S	+5I	+(?)
MACHINABILITY: Steel annealed maximum lamellar pearlite—	+2P	+3I	—2L	+6P	+10P	—2L	—2P	—10P	—4P	—1P	—(?)
TOUGHNESS: Steel fully quenched and tempered to 300 BHN—	0	—1P	0	—5P	—3P	0	0	+6P	+2S	+1P	+(?)
TOUGHNESS AT —50 F.: Steel fully quenched and tempered to 300 BHN—	0	—2P	0	—5P	—3P	0	0	+10P	+2S	+1P	+(?)
WEAR RESISTANCE: Steel fully hardened (no free ferrite) to Rc60, drawn at 300-400° F.—	0	+10P	+6P	+1P	0	+2P	+8P	+3L	+5P	+2P	+(?)
WELDABILITY: Susceptibility to small ruptures when fusion welding without pre- or postheating—	—2L	—10P	—10L	—7L	—3P	—5L	—10L	—10L	—10L	+1P	—4L

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are most effective. L means large quantities, near the top of the range, are needed. I signifies that intermediate amounts are most effective; + (?) means probably positive influence; —(?), probable negative influence. It should be remembered that merit numbers are generally based upon use of the maximum percentage shown for each element.

The toughness ratings are based on standard V notched impact for heat-treated steels. When the chart is used to arrive at the most suitable steel for a certain application, all the favorable and unfavorable points for the properties involved should be summed up so that the user can determine which alloying elements will give best results.

At present, the trend is to standardize on fewer types of steels and the use of smaller amounts of alloying elements, as in the N. E. 8000 steels.

—J. Mitchell, *Metal Progress*, Vol. 42, July 1942, pp. 53-61.

Diesel Engine Bearings

Condensed from "Mechanical Engineering"

When metals are freely available, four types of lining materials are used in diesel engine bearings: (1) Tin base; and (2) lead-base babbitt of several compositions, both in combinations with back structures of steel, bronze and cast iron; (3) cadmium-silver-copper bearing alloy; and (4) copper-lead mixtures, both in combinations with steel backs only. Connecting-rod bearings usually show distress before main bearings are affected.

The substitution of lead-base babbitt for tin-base in diesel or gasoline engine bearings is not at all gloomy. There has been a trend in this direction for main, connecting-rod and camshaft bearings for several years, the reason being improved performance.

Tests were conducted among four types: (1) Cadmium-silver copper (silver, 0.75 percent; copper, 0.50; cadmium, balance); (2) copper-lead (copper, 70 per cent, lead, 30); (3) genuine tin-base babbitt (antimony, 7.5 per cent, copper, 3.5, tin, 89); (4) Bermax high-lead babbitt (antimony, 9-11 per cent, tin, 5-7, copper, 0.25, lead, balance). In general, with good lubrication and moderate loads, temperature rise for the four types tested very closely within the range defined by tin-base babbitt bearings.

As to friction and wear, shaft wear with cadmium-silver-copper bearing was high; with copper-lead, it was worse. Wear with the high-lead was lower than with the tin base.

Tests were made with no lubrication, and it became evident that Bermax high-lead babbitt requires more lubrication than the tin-base babbitt. There is little connection between bearing performance and physical properties. In tests under heading of "Friction and Wear" hairline cracks or flaked-out areas of lining are judged to have failed. Here the Bermax showed much improved performance over the tin-base.

Superior Bermax performance, as compared with tin-base, in diameters of 1-15/16 and 2¼ in., occurred when the lining thickness was within 0.013 to 0.025 in. When thickness is heavily increased, the picture changes.

In short, field experience seems to confirm that certain lead babbitts are inferior to tin-base under conditions of scanty lubrication, heavy loads and high speeds.

From this review of the physical properties of selected bearing metals, which includes friction, wear, surface temperature, dry-shaft performance, elongation, tensile strength, Brinell hardness and bond strength, it is evident that none of these properties offers a reliable and easy guide for predicting the performance of *dissimilar* bearing metals.

With the introduction of copper-lead, cadmium alloys and one of the hardened lead-alloy bearings came bearing-surface corrosion, which does not affect tin-base babbitt or most of the lead-base babbitts. Corrosion can be kept to a minimum by correct crankcase and oil temperature, ventilation and proper oil clearance. Treatments can be applied to copper-lead and cadmium-alloy bearings, such as indium plate and diffusion, which will retard or prevent attack.

There seems to be no simple chemical tests to be applied to an oil to determine its tendency to induce or promote bearing corrosion.

—Albert B. Willi, *Mechanical Engineering*, Vol. 64, June 1942, pp. 439-448.

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by the Bridgeport Brass Co. "Bridgeport" BRASS CO *Headquarters for BRASS, BRONZE and COPPER*

Brass Is Adaptable to a Wide Range Of Fabrication and Service Needs

Desired Properties Can Easily Be Obtained by Small Changes in Composition and Proper Working

Brass is one of the most useful of all engineering materials because it has a broad range of physical properties which can easily be controlled to meet many service requirements and which are adaptable to practically any type of fabrication. These properties can be controlled by changing the copper-zinc ratio, by adding other elements, and/or by mechanical means.

Single and Two-phase Alloys

As a fabricating guide, the brasses can be broken down into two groups: (1) the alpha brasses, which have a copper content of 64% or more and form a solid ductile solution at room temperature thus making them easy to cold work, and (2) alloys of lesser copper content, which are known as two-phase alloys, because they form a second solid solution which is appreciably less ductile at room temperature and therefore less suitable for cold working. However, the two-phase alloys have excellent hot working properties because the second, or beta, solution is soft and plastic at elevated temperatures.

The straight copper-zinc series of brasses range in copper content from about 95% to 56%. In general, it may be said that strength and hardness increase as zinc is added. The changes in physical properties are not uniform, however, and there is not a proportional relation between zinc content and physical properties.

Choosing an Alpha Brass

The choice of an alpha brass often depends upon a compromise between ductility and cost. The least expensive of these alloys is Common High Brass, an alloy with the lowest copper content (64%) of those which contain simply the ductile alpha solution. This alloy finds wide application for electrical fittings and small parts, such as screws and rivets. When the copper content of brass reaches 70%, an alloy combining strength and ductility is achieved that can be used for such deep drawing operations as the fabrication of cartridge cases. For this reason, 70-30 brass is generally known as Cartridge Brass. The accompanying graphs show how this alloy reacts to drawing and annealing.

Among the other widely used brasses of high copper content are the following: Gilding Metal (95-5), an alloy not much stronger than copper but very ductile and easily worked both hot and cold; Commercial Bronze (90-10), favored for its rich "bronze" color and comparatively high melting point; Rich Low, or Red Brass (85-15), noted for excellent resistance to failure by season cracking and dezincification; and Low Brass (80-20), an intermediate alloy limited largely to applications which require maximum strength and reasonable freedom from season cracking.

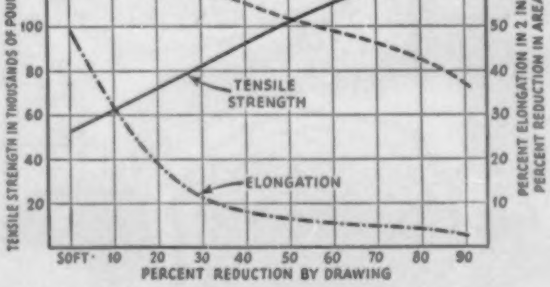
The most commonly used two-phase brass is an alloy of approximately 60% copper and 40% zinc known as Muntz Metal which has excellent hot working properties under most conditions. As might be expected, however, it is somewhat harder and less ductile at room temperature than most of the other copper-zinc alloys. Other properties of Muntz Metal include resistance to failure by season cracking or stress corrosion equal to that of regular high brass, fairly good resistance to attack by sulphur compounds, and low cost. This alloy should not be used where conditions favorable to dezincification are present.

Modifying Elements

A third or fourth element is added to copper-zinc alloys when some specific improvement is desired. By far the most important of such elements is lead because it imparts machineability. Unfortunately, the addition of lead makes it difficult to hot work alloys with copper contents above 63% and also makes them sensitive to processing variables in cold working. Therefore the use of lead in brass is largely confined to alloys in which the copper content is in the 55-63% range, such as Screw Machine Rod, Leaded Cold Heading Rod, Forging Rod, Leaded Naval Brass and Clock Brass.

The addition of about 1% silicon to Common High Brass will change it from an alpha solid solution alloy to a two-phase alloy very similar in structure and physical properties to Muntz Metal. Such an addition therefore makes it possible to hot work an alloy of

(Continued on page 2, column 2)



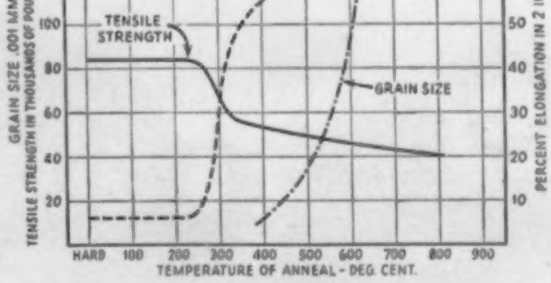
Effect of Cold Drawing on Mechanical Properties of 70-30 Brass Rod or Wire.

Copper Alloys Found Superior For Use In Photographic Parts

"After more than thirty years experience in the manufacture, research and engineering of our products, we have concluded that copper base alloys are more suitable to our products than other types of metals," it is stated by the Ilex Optical Company, of Rochester, N. Y., makers of photographic equipment. Machineability, stability and durability are the reasons given by the company for the almost exclusive use of copper alloys in the production of metal parts for their products.

Sheet brass, leaded brass tubing and brass rod are normally used by the Ilex Optical Company in the production of lenses, shutters, mountings and housings. Brass rod or

brass tubing, for example, is used for lens cells, while thin gage rich-low brass sheet approximately 6 numbers hard is used for the leaves in the diaphragms of lens barrels. Such parts of photographic shutters as the housings, levers and face plates are made of either bronze castings or brass sheet. Likewise all small screw machine parts, such as screws, rivets, axles, posts and pivots, are formed from bronze or brass rod.



Effect of Annealing on Mechanical Properties of 70-30 Brass Sheet.

COPPER ALLOY BULLETIN

ALLOYS OF COPPER

This the is thirty-eighth of a series of articles on the properties and uses of the copper alloys.

COPPER ALLOYS FOR CATENARY CONSTRUCTION PHONO HIGH STRENGTH No. 813

The catenary supporting wires, or messengers, on early electrified railroad systems were made of steel. Since the problem of corrosion was a serious one, Bridgeport Brass Company, about 20 years ago, undertook the development of a high strength corrosion resistant copper alloy wire which was designated as Phono High Strength. This alloy contains approximately 97.60% copper, 1.40% tin and 1% silicon. It has an electrical conductivity of about 13% as compared to copper. Its physical properties follow:

Specific Gravity, Hard Drawn	8.78
Wt. lbs./cu. in.	.3172
Wt. lbs./circ. mil. ft.	0.000002989
Min. elec. cond. I.A.C.S.	13%
Max. elec. res. Ohms/circ. mil. ft.	79.78
Ccef. of line. expansion/°F	0.0000094
Thermal con. (approx. % cop.)	20%
Tensile Strength, lbs./sq. in. Hard Drawn	70-135,000
Annealed	43-50,000
% Elon. in 60″ Hd. Dr. Wire	0.85-1.50
% Elon. in 10″ Hd. Dr. Rod	1.75-10.0
% Elon. in 2″ Hd. Dr. Wire	5.0-20.0
% Elon. in 2″ Annealed Wire	40.0-60.0
% Reduc. in Area Hd. Dr. Wire	50-80
% Red. in Area Annealed Wire	75-85
Johnson's El. Li., (%T.S.) Hd. Dr.	60-75
Modulus of Elasticity	15,000,000
Magnetic Properties	Non Mag.

In electrified steam railway construction, the entire overhead is stranded wire except for contact and possibly auxiliary wire. The messenger wires are live wires; consequently, electrical conductivity is very important. When higher conductivity than 13% is desired, the stranded cable is made up of a combination of Phono High Strength and hard drawn copper wires with consequent loss in strength.

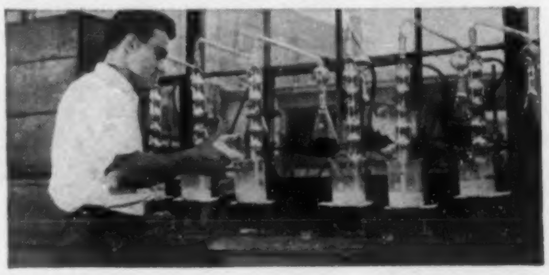
Because of its fine properties—high strength, resistance to corrosion from the elements, great toughness, and good workability—Phono High Strength was soon adopted for the manufacture of pole line and signal hardware, wire clamps, U bolts, machine, wood and cap screws, nuts, lockwashers, water meter parts, and marine hardware. Such items are generally made from hard drawn wire which is not only very strong but remarkably malleable.

Brass Is Adaptable

(Continued from page 1, column 3)

practically the same composition as Common High Brass, yet with properties similar to Muntz Metal. The addition of silicon also makes it possible to spot weld an alloy of more than 80% copper as it lowers thermal and electrical conductivity.

Tin, when added to copper-zinc alloys, reduces corrosion (particularly from sea water) by retarding dezincification. It also adds strength and makes the polished metal lighter in color. The substitution of 1% of tin for a corresponding amount of zinc in Cartridge Brass, for example, produces an alloy suitable for condenser tubing which is



Part of the complete equipment in Bridgeport's Research Laboratory for the study of copper and copper alloys is this apparatus with which the arsenic content of brass is determined, in order to evaluate its effect.

known as Admiralty Metal. Further steps are taken to prevent dezincification of Admiralty Metal by the addition of Arsenic, antimony and phosphorus. Aluminum increases the corrosion resistance of copper-zinc alloys but for a different reason. It forms a strong oxide film which increases the protective film normally formed on brass thus making the metal more resistant to erosion and subsequent corrosion. Another property of aluminum is to raise the tensile strength of brass as it does in high strength manganese bronzes.

In addition to the methods mentioned, the physical properties of brass can also be altered by suitable processing. Strength, stiffness and spring properties can be improved by cold rolling or drawing and ductility increased by annealing or heat treatment. In the soft condition, for example, brasses range from 45,000 to 65,000 pounds per square inch in tensile strength while they may range from 65,000 to 100,000 when cold worked.

Today when quality is so vital and metals so scarce, both the selection of the *best* brass for any particular application and its proper fabrication are of special importance. Bridgeport's laboratory technicians will be glad to advise fabricators on these problems.

NEW DEVELOPMENTS

A precision inspection instrument is announced which is described as a visual indicator comparator gage designed especially to facilitate inspection of close tolerance parts. It has built-in limit indicators to copy the range of tolerance from master parts and is said to multiply dimensions by as much as 200. It is adjustable for use on snap gaging operations or with built-in button retractor, for gaging plunger. **(No. 370)**

A colorless liquid leak sealer is announced as offering a quick way to stop leaks in concrete walls, tunnels, floors, tanks and pits. It is mixed with ordinary cement and molded into a carrot that can be forced into the opening. This sealer is said to stop leaks immediately even against intense pressure. **(No. 371)**

A heavy-duty non-skid C-clamp has been placed on the market. The screw is provided at the clamping tip with a bronze bushing which is designed to prevent galling and provide free movement, so that slippage on work is eliminated. **(No. 372)**

A coupling head thermo-switch has been designed for insertion into a closed liquid or gas system by means of a half-inch standard pipe thread. It has a brass shell and is available in models with contacts which open on increases and decreases in temperature. The adjustable operating range is 50 to 400° F. Contacts are rated at 10 amp at 115 v and 5 amp at 230 v. This unit is also available with 25 amp capacity and can be furnished for operation up to 600° F. **(No. 373)**

A metal parts washer is announced which is said to be adaptable for cleaning war production parts, shell cartridges and munitions parts. It offers a long dormant soak besides the customary method of powerful hydro washing. The unit can be used for soaking, washing, drying and the preparation of metal parts either machined, or rough, and for complete assemblies. **(No. 374)**

An acid and alkali resistant paint is offered made from domestic waxes in Indian red color. It is said to dry very quickly allowing several coats to be applied in a day. The maker says it requires no priming coat and will adhere to iron, steel, non-ferrous metals, wood, stone and cement. **(No. 375)**

A tube cutting attachment is offered which can be adapted to all sizes of nibblers and is said to save hours of time. The cutting speed is about 36 inches per minute. Set-up time, it is claimed, can be reduced over normal methods and nibbling does not require a skilled operator. The use of a standard punch is said to keep tool cost to a minimum. **(No. 376)**

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

4 Testing and Control

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection • Routine Control and Instrumentation • X-ray and Magnetic Inspection • Spectrographic and Photoelastic Analysis • Corrosion- and Wear-Testing • Examination of Coatings, Surface Measurements • Metallographic Structure and Constitution

CONTENTS

Infra-Red-Ray Weld Testing

Condensed from "The Welding Journal"

Photographic work of etched sections of welded joints, as a means of identifying degree of fusion, impurities and heat-affected zone, is usually carried out under conditions where white light is used as the source of illumination. The successful use of infra-red light as an illuminating source for documentary, aerial and medical photography led the author to a consideration of the use of infra-red to photograph metallic specimens.

Infra-red light was chosen for these investigations since all metals act as almost perfect reflectors to this type of light, and photographic equipment to suit is readily available. It is only necessary to cover the lens with a filter of the desired wavelength and use a film sensitized for the infra-red.

Satisfactory developing solutions for infra-red film and the corresponding conditions of time and temperature are given in a list. The conditions laid down must be closely observed in that infra-red film must be processed in total darkness, thus preventing examination during development.

Macro photographs of joints are presented, comparing white light photographs with infra-red ones on the same specimen. A sharper contrast between light and dark components is apparent. Grain structure is clearly outlined by the infra-red, and a greater contrast is obtained between the weld metal, zone of fusion and heat affected zone, and defects are clearly indicated.

Longer exposure times are necessary to secure satisfactory prints from infra-red negatives. Exposure times can be reduced by increasing the temperature of the specimen, which, incidentally, should always be kept below the lower critical point of the metal, so that no structural changes are produced that were not present due to the welding process.

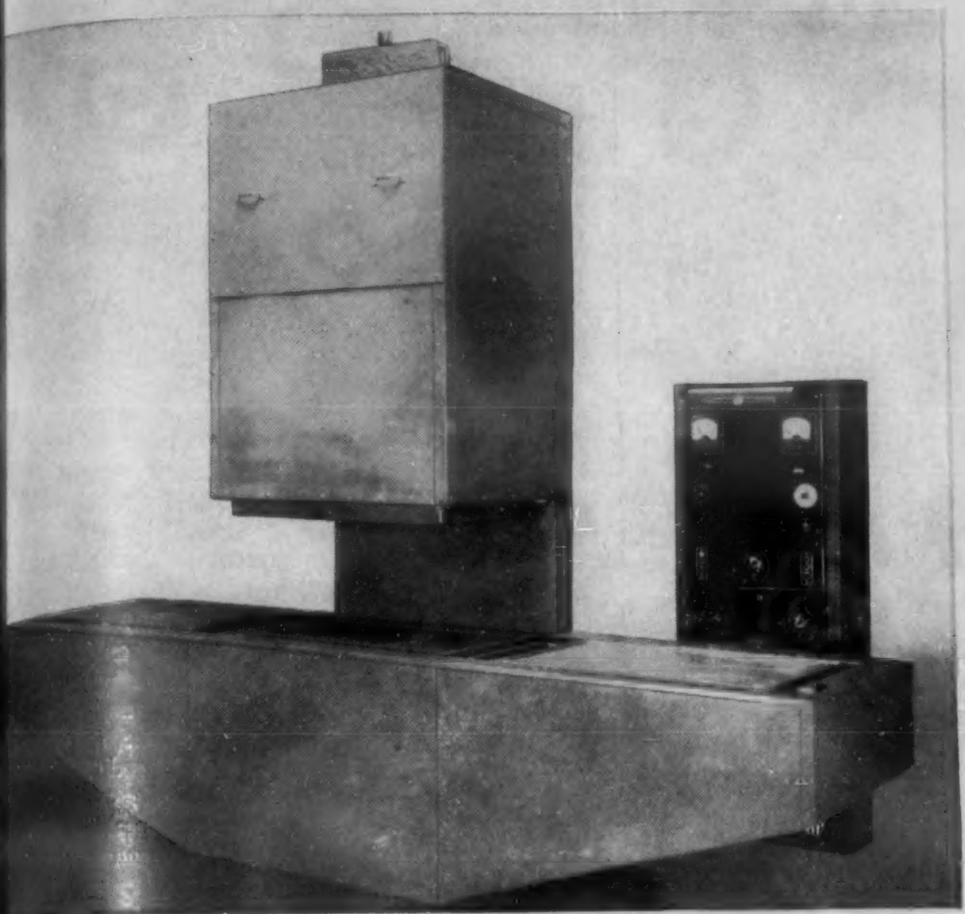
—W. T. Tiffin, *Welding J.*, Vol. 4, May 1942, No. 940.

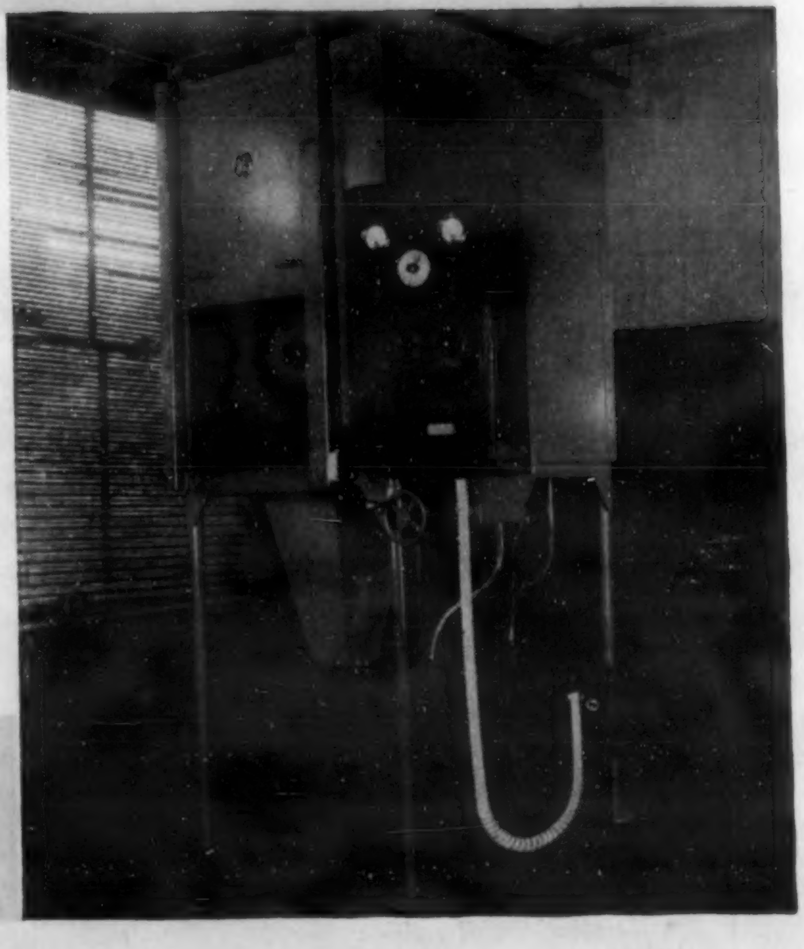
X-ray of Aircraft Castings

Condensed from "Journal of the Aeronautical Sciences"

A concerted effort made by the Engineering Department at Lockheed to build up an effective control of X-ray inspection resulted in adoption of the following conclusions: There must be specifications dealing separately with forgings, castings, and X-ray magnetic and other special inspection procedures. A strict control must be maintained in the selection of parts given X-ray inspection and the determination of the correct percentage in each case of the parts received to be submitted to such inspection. The primary purpose of X-ray inspection is to serve as a creative means for improving the quality of castings, and its use as a tool in large-scale routine inspection, except for special classes of parts, is secondary.

Responsible structural engineers prepared clear and separate specifications and listed all castings and forgings used on each of the models with their classification as to structural importance and per cent X-





ray, magnetic, sectional and physical test requirements in accordance with existing government rulings. Concurrently a detailed statistical investigation covering 25 months was made. It was based on reports on specific parts prepared by the X-ray Laboratory. Information was also available as to the type of pattern equipment used for all castings.

This intensive study led to the belief that insufficient correlation between the seriousness of defects shown by a radiograph and the results of structural breakdown tests has led to the rejection of thousands of parts perfectly airworthy even though containing defects.

What Causes Rejections?

Determination of the relation between the percent rejection and the number of lots received showed that rejections were high for initial lots, dropped rapidly with succeeding lots and slowly decreased until asymptotic to a definite percentage characteristic of each of the alloys.

For a period from November 1939 to March 1941, rejections for 195T6 castings were twice those for 220T4 alloy, and rejections for magnesium alloy castings ½ those for 220T4. As these were in inverse order to the relative casting difficulties for these alloys, the probable explanation is that the knowledge of greater difficulty causes more care and attention to be given to foundry technique.

An analysis of rejections for eleven months, January to November 1941, showed that the rejection rate for 220T4 alloy has been slightly lowered and that for 195T6 alloy, drastically reduced until only slightly more than that of the former. This shows the value of analysis in revealing weaknesses and making possible marked improvement in quality.

Another point proved was that with the exception of the 220T4 alloy, where the rejection rate was already relatively low, there was a reduction of 37 per cent in rejections obtained through the use of permanent metal plate or wood board patterns as compared with either metal or wood loose patterns. The former also require less skilled workmen and increase production rates. Such replacement of equipment should be worth the entire cost of the investigation.

A startling difference in quality of castings produced by different vendors was shown. Therefore, one of the most valuable services of X-ray inspection lies in the selection of reliable vendors.

Finally, the statistical analysis proved that dross and porosity, both under control of the foundry, and the least serious from an airworthiness view, accounted for about 75-90 per cent of total rejections, and that this rate was considerably improved in 1941 in comparison with 1940. The most serious defects—shrinkage and cracks—accounted for 3-5 per cent of rejections in 195T6 and 10-14 per cent in 220T4.

General conclusions from the statistical analysis are as follows:

(1) Close coordination is necessary between design groups, inspection and purchasing departments and foundries. The results of inspection must be made immediately available to the control engineer.

(2) For initial forgings, defects can best be determined by sectioning at critical points and studying photomicrographs. Sound forgings having been obtained, no special inspection is necessary.

(3) Casting rejections are more difficult to control but if a certain fault, except dross and porosity, keeps recurring, the design is usually at fault.

(4) To determine the ability of parts to hold hydraulic pressure, a hydraulic pressure test is essential and X-ray inspection is unnecessary after it has been used to establish proper design and foundry technique.

(5) Large cost savings can be made by careful control of X-ray inspection and by correlating it both with the structural importance of the part and the percentage of rejection. There should be correlation with the actual strength of the part as determined by static test.

(6) The best primary form of control is a graph for each part, showing percentage of rejection versus the lot number.

X-ray Inspection Control

To secure effective control of X-ray inspection, it was found that it was essential to centralize control in one office. In the Lockheed organization, this was the office of the materials and processes staff engineer. Other groups furnished data and reports, and that office made recommendations to other groups.

A program was carried on for over a year to correlate radiographs of aluminum alloy castings with their structural characteristics, with the primary emphasis on impact and fatigue. The following conclusions may be drawn:

(1) Cracks have a serious effect on the strength properties of a casting. They are particularly critical if at right angles to a major stress, but are cause for rejection even though parallel.

(2) Shrinkage or channel porosity and segregation, when oriented normal to the direction of stress, reduce fatigue and impact characteristics.

(3) Dross and blowholes have only a slight effect unless they are major and/or located in a critical section.

(4) Pinhole porosity, aside from lowering ductility and decreasing corrosion resistance, is in general less serious than other defects.

Similar tests made by the Aluminum Company of America presented conclusions generally corroborated by the Lockheed experience.

Two related statements, based on the two programs may be made:

(1) In general, because of excess strength either required by government rulings or due to excess material provided by the design, castings having minor defects need not be rejected.

(2) Even though the casting is an important structural part, if the ratio of the breaking load to its normal design load is high, the writer believes that 100 per cent X-ray is not required after development of correct foundry technique, and a lower X-ray quality is acceptable than in the case of a similar part having the minimum ratio of 2.

—B. C. Boulton, *J. Aeronautical Sciences*, Vol. 9, June, 1942, pp. 271-283

The Spectrograph and Steelmaking

Condensed from "Blast Furnace and Steel Plant"

One of the causes for time lost and delay in tapping the open-hearth furnaces at Weirton was the tedious and long "wet method" for determining copper and tin, which varied considerably from heat to heat.

Prior to the installation of a spectrograph, copper preliminaries were taking 3-5 hrs., before tapping time. Owing to the necessity of taking this test so long before tap, there was quite often a large variation between the preliminary and the ladle test. Normally this variation would require a heat to be diverted into an order for which it was not scheduled.

The tin preliminaries were taking 1-1½ hrs., before tapping time, or when the carbon, phosphorus, etc., were worked out sufficiently to make the tin determination accurately. Occasionally, the results were not obtained until almost tapping time, and were then found to be out of specification, necessitating a change of molds and the reordering of another heat.


Precision for WAR..

The development of the spectrograph in the past few years gave assurance that some of these elements, which have been time wasters in the past, might be brought under control by use of this instrument; accordingly, the Weirton Steel Co. decided to purchase a spectrograph.

The spectrograph was installed in the chemical laboratory and standardization began on July 7, 1941. By Aug. 25 standardization had progressed to the extent that copper was being reported as a routine analysis on both preliminaries and heats. By Sept. 10, the tin determination had been added, and shortly afterward chromium was included.

By the spectrograph one set of pin tests is taken 1-1½ hrs. before tapping time; and copper, tin and chromium are reported to the open-hearth and the blooming mill in 25-30 mins. The pin tests are made in a special mold with two 7/32 in. holes in the bottom. The steel is thoroughly killed with virgin aluminum before pouring the test. We are operating this equipment, with one graduate spectroscopist, and one man on each turn.

In conclusion, we have found the spectrograph has eliminated all the lost time, at the open-hearth and blooming mill, due to the speed and accuracy of the results obtained, as compared to the longer and more tedious methods mentioned. Other than the time saved, this equipment has paid for itself in qualitative and quantitative analysis on many other samples.

—J. A. Sample, *Blast Furnace & Steel Plant*, Vol. 30, Aug. 1942, pp. 875-876.

Damping Capacity

Condensed from a Paper before the North-East Coast Instn. of Engrs. & Shipbuilders

The authors report on an investigation of the damping capacity of plain and alloy steels, propeller materials such as cast iron and copper-zinc alloys, nickel-iron alloys, Monel metal, bronze, aluminum alloys, magnesium alloys, metallic nickel and cobalt, glass, ivory, ivorine and various bakelites.

A testing apparatus was designed capable of giving results over a wide range of temperatures; this is described and illustrated. It incorporated a magnetic method of deflecting the specimen, the deflection of which was recorded optically by the reflection of a beam of light from a galvanometer lamp at two mirrors, one on the frame of the apparatus and one on the swingbar; the light was then passed to a camera with a continuously moving 35-mm. film.

Examples were noted of both increases and decreases in damping with increase in temperature, while in other cases over a wide range of temperature changes in damping were comparatively slight. The truly austenitic alloys showed relatively low values of damping, while the stainless materials of the 13 per cent Cr type gage particularly high values. Low carbon steel had an intermediate value.

A comparison of the results, which are presented in tables, reveals that the values for sintered carbides, although a little higher than those for cobalt (one of the constituents of the sinter) were nevertheless of the same order of magnitude. It seems very likely that a hard chemical compound such as tungsten carbide will not have a very high damping capacity, and the cobalt may be responsible for most of the damping recorded. By the same reasoning, the cementite occurring in carbon and alloy steels may not contribute a great deal to the damping, although in this case the relative amounts of carbide and matrix are very different.

The exceptionally high values of damping capacity observed in nickel at room temperature were remarkable. The crystal structure of nickel is similar to that of the alloy steel containing 25 per cent Cr and 20 per cent Ni, yet this alloy, unlike nickel, had a particularly low damping capacity; nickel has distinctive ferro-magnetic properties, unlike the above alloy, which is non-magnetic, and it is pointed out that other austenitic alloys that are slightly magnetic have higher damping capacities than the above alloy.

From the results on cobalt, nickel and the nickel-iron alloy with 36 per cent of nickel, it would also appear that magnetic influences are important, but beyond this it is not possible to suggest an explanation of the results obtained.

—W. H. Hatfield, G. Stanfield & L. Rotherham. Paper before the *North-East Coast Instn. of Engrs. & Shipbuilders*, May 1942.

books

FOR METALLURGICAL ENGINEERS

Alloy Steels

ALLOY CONSTRUCTIONAL STEELS. *By Herbert J. French. With a section on Corrosion in collaboration with Francis L. LaQue. Published by the American Society for Metals, Cleveland, Ohio, 1942. Cloth, 6¼ x 9¼ in., 294 pages. Price $4.00.*

A continuous effort has been in progress since 1930 to classify our knowledge of alloying elements in steel. It has been one of the achievements of recent years that alloy steel problems have been sent so far along the road of co-ordination with fundamental principles in so short a time.

This book by Mr. French is not the first, nor will it be the last, attempt to summarize the knowledge which has been accumulated for the purpose of appraising low alloy steels on a factual basis. The book interprets the recently developed classification of alloy steels in terms more often sought by the engineer than by the research metallurgist. It touches upon the similarity of the various popular alloy compositions in heat-treated steels, a point which is not yet as widely accepted by engineers as it should be.

Several chapters of the book are devoted to the less readily appraised characteristics of steels such as Low Temperature Impact, Elevated Temperature Strength, Wear Resistance and Corrosion Resistance. By reading these chapters the engineer can learn how complicated the metallurgical aspects really are in evaluation of this class of properties.

The book is definitely written to present a broad picture rather than to be a reference work on the subject. In the author's own words, "The details and individual illustrations may be somewhat less important than the principal theme." It can be recommended to engineers who wish to familiarize themselves with the problems which the metallurgist has to solve in reducing scientific investigation to useful specifications. It can also be recommended to those metallurgists who want to follow in detail the efforts to establish a scientific basis for the selection of alloy combinations in steel.

—A. J. HERZIG

Electroplating

MODERN ELECTROPLATING. *Published by The Electrochemical Society, Inc., New York, 1942. Cloth, 6¼ x 9¼ in., 399 pages. Price $5.50.*

During recent years the literature on principles and methods of electroplating has increased so rapidly that even specialists in this field have found it practically impossible to keep posted on the developments. Recognition of this situation led the Electrodeposition Division of the Electrochemical Society to hold a general symposium on electroplating at the 80th meeting of the Society in Chicago in October, 1941. The papers and discussions at that symposium have been assembled in this special volume.

The book contains 19 papers prepared by a total of 26 authors. Practically every phase of modern commercial plating practice is considered, including general principles and methods of plating and of testing solutions and deposits. Methods of alloy plating, including brass plating, are described. The other chapters include cadmium, chromium, cobalt, acid and cyanide copper baths, gold, iron, lead, nickel, platinum, silver, acid and alkaline tin baths, and acid and alkaline zinc baths. No attempt was made to include exhaustive bibliographies, but each chapter contains references to important publications on that subject.

This volume fills a real need for a reference book in this field. It should prove almost indispensable to platers, chemists, metallurgists and executives who are concerned with developments and applications of electroplating.

—WILLIAM BLUM

Treatise on Hardness

HARDNESS AND HARDNESS MEASUREMENTS. *By Samuel R. Williams. Published by American Society for Metals, Cleveland, Ohio, 1942. Cloth, 6¼ x 9¼ in., 558 pages. Price $7.50.*

It is regrettable that the first book on this subject written by a physicist fails completely in attaining its goals. According to the author's preface, "This treatise on hardness and hardness measurements is a pioneer attempt on the part of a physicist to clarify concepts of hardness and to improve the methods for measuring hardness, *if such a property exists*." (Author's italics)

The author has been notably successful in assembling a considerable number of references to investigations reported prior to 1900. Quotations and conclusions from these venerable works are used freely without attempting to evaluate them in the light of more recently acquired knowledge. An extensive bibliography at the end of the book includes references to the more recent investigations, but these apparently were used sparingly in preparing the text.

Descriptions of commercial hardness testing machines and their operations are covered rather completely in 15 pages of catalog type of information on the Brinell test, 17 on Rockwell, 20 on diamond pyramid tests, 7 on Monotron, 11 on scleroscope, and 20 on Herbert pendulum. However, the section on Brinell tests does not mention the use of tungsten-carbide balls or the time of load applications.

In a special 18-page chapter on portable Brinell type testers, no mention is made of the excellent King instrument made in the United States, which is certainly of more interest than most of the foreign-made machines described.

For the reader who does not have a 1939 ASM Metals Handbook, 24 pages of useful and concise data on hardness tests taken from this source are included as an appendix.

Turning to the more theoretical sections of the book, one finds little information on the problems which are of interest to those working in this field. Chapters on atomic structure, theories of hardness and hardness measurements, and wear resistance are followed by three chapters on early, recent, and modern scratch hardness measurements. Throughout the book, and especially in this section, the author emphasizes his viewpoint that hardness be considered from a general and not merely a metallurgical standpoint.

A short chapter is devoted to early investigations of penetration hardness methods. The chapter on "Physical Processes which Occur at the Point where a Hardness Test is Made" is extremely superficial and padded with irrelevant material. A 12-page section on room temperature creep testing includes, for example, a test on a rubber tube filled with sand and water, placed on supports, and permitted to sag because of the strains set up by its own weight.

A final section of 71 pages deals with the correlation of hardness with magnetic

(Continued on page 835)

and electrical properties including magnetostriction. The old problem of changes in hardness upon magnetization is aired and the author takes the affirmative stand with E. G. Herbert.

The publication of Hugh O'Neill's book in 1934 did much to clarify our concepts of hardness measurements at least to the extent of collecting and correlating the important research investigations to that date. It will be unfortunate indeed if the present book reverses the process and muddies the water to such an extent that a period of stagnation will be required to restore visibility.

This book falls far short of the high standards set by recent A.S.M. publications of this type.

—R. H. HEYER

Powder Metallurgy

POWDER METALLURGY. *Edited by John Wulff. Published by American Society for Metals, Cleveland, 1942. Cloth, 6 x 9 in., 622 pages. Price $7.50.*

The papers given at the 1940 and 1941 powder metallurgy conferences at M.I.T., heretofore available only in mimeographed form, are printed here, together with a few articles elsewhere published.

The 51 chapters cover a wide range and vary from a broad consideration of fundamentals to laboratory reports on unfinished investigations of very limited scope. Some attention is paid to almost everything that is made from solid metal in a fine state of subdivision, so a vast deal of somewhat, but not very closely, related information is set forth.

The basic limitation of present processes comes out in the fact that every object made that does not require further fabrication is quite small. Coalesced copper is made up to 4½ in. in diameter, but that is intended for further working by conventional methods. Practically everything else that is made in any quantity can be lifted with one hand, usually with one finger. There are lots of little gadgets that are important gadgets, but the range of sizes of powder metallurgy products is very restricted compared to that nicely made by die casting.

The features that limit the present sizes are discussed in many of the chapters, much more often from the point of view that the limitations are insurmountable than from that of a determination to surmount them.

Because high-priced materials and materials not easily amenable to other modes of processing have been so much used in powder metallurgy, the book contains a good many side comments on phases of metallurgical engineering not much touched upon in the usual text books and handbooks. Hence, any engineer will find many parts of the book both interesting and useful even if he has no direct interest in powder metallurgy itself.

—H. W. GILLETT

COLD FINISHED BAR STEELS. *Published by Bliss & Laughlin, Inc., Harvey, Ill., and Buffalo, N. Y., 1941. Cardboard, 6 x 9 in., 226 pages. Price $2.00.* This handbook, issued at the 50th anniversary of the firm, describes production, inspection, and testing of cold-drawn bars and has a technical section on metallurgy, metallography, grain size, machinability, etc. The data section includes conversion, machining, and weight tables.

Other New Books

CODE OF MINIMUM REQUIREMENTS FOR INSTRUCTION OF WELDING OPERATORS, PART A—ARC WELDING OF STEEL 3/16 TO 3/4 IN. THICK. *Published by American Welding Society, New York, 1942. Paper, 6 x 9 in., 68 pages. Price 50 cents.* This code represents a revision of the "proposed code" that was issued by the Society in 1941 and widely circulated. In this revision, there has been considerable expansion, particularly as to the supplementary material in the appendices. Sections in the main body of the code include: Equipment and facilities of the school; instruction in welding practice; instruction in welding theory, and so on. There are 9 appendices of suggested and recommended material.

TENTATIVE STANDARDS AND RECOMMENDED PRACTICES AND PROCEDURES FOR SPOT WELDING OF ALUMINUM ALLOYS. *Published by American Welding Society, New York, 1942. Paper, 8½ x 11 in., 48 pages. Price $1.00.* This is an Emergency Standard and is the result of 9 months of concentrated work by a technical committee. It represents tentative recommendations for standards of weld quality and performance as well as general recommendations of the best practices and procedures to be followed in spot welding of aluminum alloys in the aircraft industry. The theory of spot welding is fully discussed. The report is an attempt to provide a practical guide and reference book for anyone engaged in spot welding of aluminum alloys.

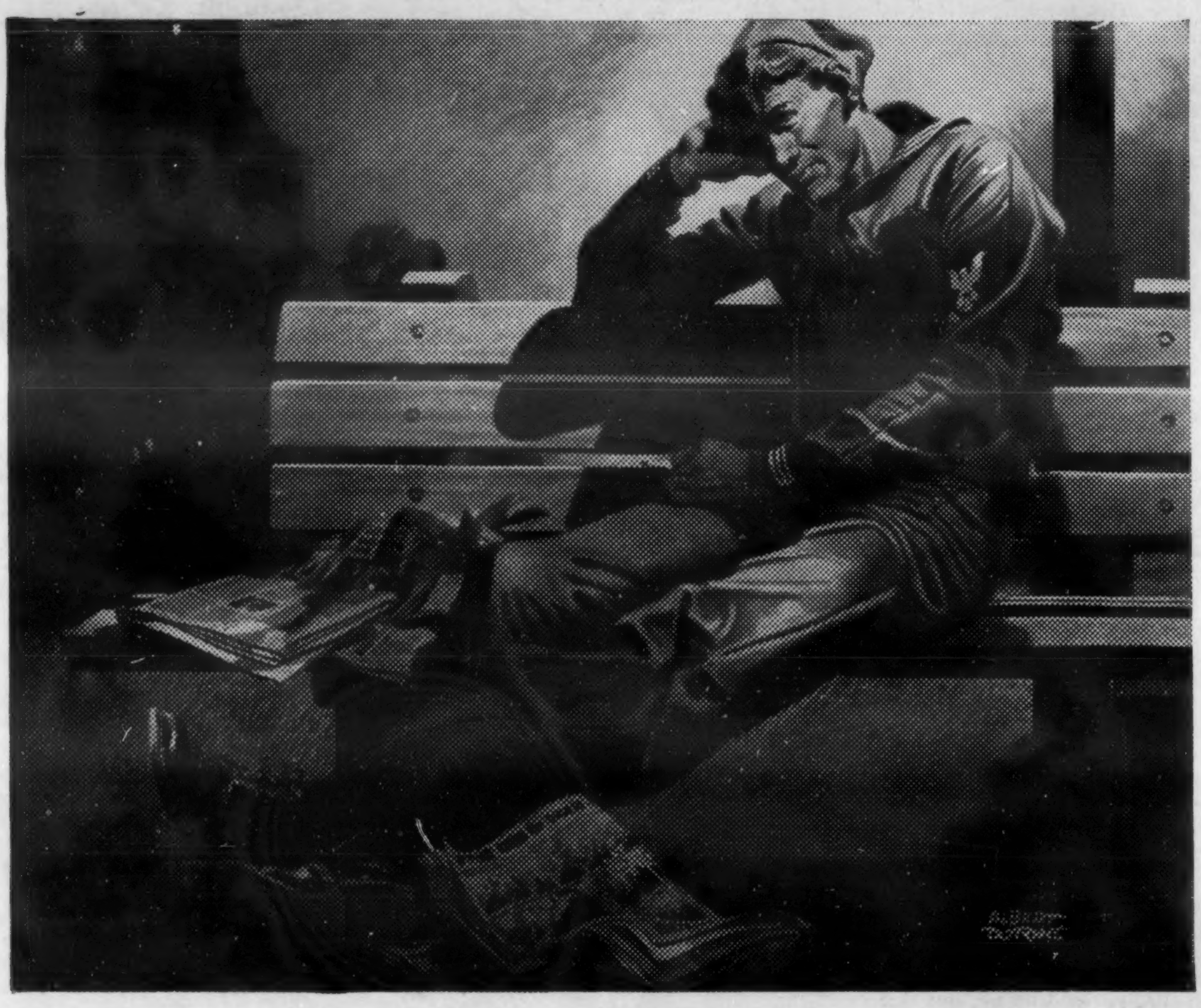
LESSONS IN PRACTICAL ARC WELDING. *By W. J. Chaffee. Published by Hobart Trade School, Inc., Troy, Ohio, 1942. Paper, 5½ x 8 in., 188 pages. Price 75c.* The complete series of 41 arc welding lessons offered at the Hobart Trade School is contained in this book. Some of the chapters include: Starting and Manipulating the Arc; Welding Light Gage Sheets with Coated Electrodes; Pipe Welding; Welding Cast Iron; Special Practice and Tests. Suggested classroom procedure and a ready reference text are included.

PLANT EFFICIENCY—IDEAS AND SUGGESTIONS ON INCREASING EFFICIENCY IN SMALLER PLANTS. *Published by Division of Information, Office for Emergency Management, Washington, D. C., 1942. Free upon request.* Couched in simple terms, this booklet is designed primarily for smaller war plants or for plants which are just getting into war production. Some of the chapter headings include: Cutting Down Accidents; Adapting Old Machines to New Jobs; Getting the Most out of Machine Tools; Training Workers Quickly; Pooling Facilities and Plant Protection.

STEEL HANDBOOK NO. 42 FOR MACHINE TOOL USERS. *Published by Union Drawn Steel Div., Republic Steel Corp., Massillon, Ohio, 1942. Fabrikoid, 5 x 8¼ in., 83 pages. Free on request.* This fifth edition is a wartime edition. A feature is the publication for the first time of the combined standard steel lists of the American Iron and Steel Institute and the Society of Automotive Engineers for carbon and alloy steel bars with suggested speeds for machining many of these grades with standard tools, as automatic screw machines. Many important tables are included. Intended primarily for those who operate and plan work for automatic screw machines, it contains much information valuable and useful to others interested in the machining of metals.

STANDARD METHODS FOR MECHANICAL TESTING OF WELDS. *Published by American Welding Society, New York, 1942. Paper, 6 x 9 in., 25 pages. Price 40c.* The principal mechanical tests applied to welds—for density, soundness, tensile strength and ductility—are described in some detail. Sketches of the specimens and descriptions of the methods of testing and evaluating results are included, plus a section on etching reagents and procedure.

DEFINITIONS OF WELDING TERMS AND MASTER CHART OF WELDING PROCESSES. *Published by American Welding Society, New York, 1942. Paper, 6 x 9 in., 32 pages. Price 40c.* The standard definitions of welding terms, adopted by the American Welding Society are included, grouped under appropriate headings. There is also an index of all terms alphabetically arranged. Over 50 illustrations assist in clarifying the definitions.



trends

By Edwin F. Cone, Editor

Assembling Bombers

Our larger airplanes, or bombers, are an enormous job of assembly as compared to the earlier planes. We read in an editorial in the *New York Times* that into a B-24 four-motored bomber go 106,500 separate parts, not counting 600,000 nuts, bolts and rivets. "Yet the rate of assembly of such a bomber is reduced to that of its slowest element." Any slowdown in the delivery of any of these many parts may mean a delay that is disastrous.

Raw Material Consumption

To produce the approximately 62,300,000 tons of finished steel products last year, nearly 4 tons of raw materials for each ton of finished product was consumed, says the Amer. Iron and Steel Institute. Almost 227,000,000 tons of raw materials were charged into American blast and steel making furnaces during 1941.

More Mercury

One of the many results of the nationwide search for strategic and other minerals has been the discovery of a new, high-grade deposit of mercury-bearing ore in the Yellow Pine area of Idaho. Tests of drill samples show existence of ore averaging 11 lbs. of mercury per ton with one 5-ft. section averaging 22 lbs. per ton.

Canadian Steel and Pig Iron

Canada's production of pig iron and steel is expanding similar to the trend in this country. The pig iron output is now (to June 1942) at the rate of 215,325 net tons per month; in 1941 for the same period it was 114,965 tons per month. In steel the rate this year has advanced from 161,208 tons monthly in 1941 to 261,015 tons per month now.

Labor Migration

Because of the pirating and migration of labor in the mining to other higher paying industries, the country has suffered a loss of 11,000 tons in the production of copper during June and July, said Paul V. McNutt, chairman of the War Manpower Commission in a recent statement. In 12 Western States, labor has been frozen and labor is forbidden to migrate without a "certificate of separation."

Detinning Capacity

An announcement by WPB is to the effect that the nation's detinning plants now have the capacity for salvaging more than 3,000 tons of tin and 297,000 tons of steel scrap per year. By the middle of 1943 the capacity rating is expected to be about 5,000 tons of tin and 495,000 tons of steel annually.

The Scrap Steel Shortage

It is reliably estimated that steel mills' inventories of scrap iron and steel have shrunk approximately 40 per cent over the last 18 months of record-breaking steel output. They now (Sept.) represent an average for the entire steel industry of between 2 and 3 weeks' supply. Stocks on hand Jan. 1, 1941, totaled about 3,934,000 tons but on July 1, this year, this was down to only 2,429,000 tons in mills' storage yards.

Large exports of semi-finished steel to England have deprived American mills of one of their major sources of scrap.

Freight Equipment

According to a survey by the *Railway Age*, this fall American railroads will have barely enough freight locomotives and a shortage of open-top cars. The question is raised· Is the War Production Board, by not increasing allocations of materials for railway purposes, acting in the best interests of the country? The railroads are running close to a shortage of equipment, it is contended. A big recent allocation is reported to have been made.

Machine Tools

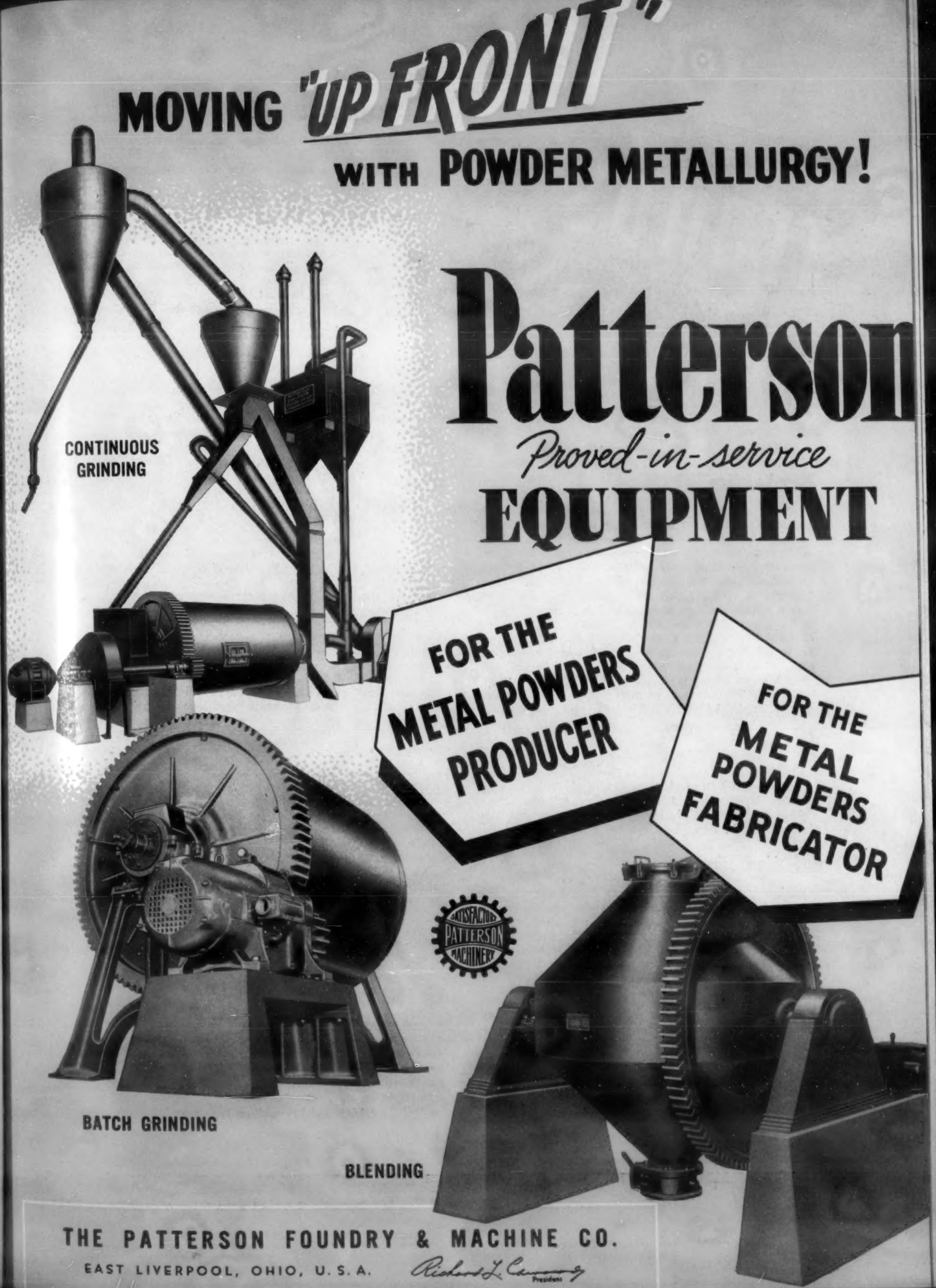
Records, hardly believed possible a few years ago, are now being made by the machine tool industry. The industry is producing more machine tools per month than it formerly built in many full years. For the first half of 1942, the output has been valued at $558,076,000 or a gain of 61.2 per cent over the $346,200,000 for the same period in 1941.

There are 325 companies making machine tools in the country today. Beside these there are 60 sub-contractors. It is estimated that about 14 per cent of the total output is supplied by the subcontractors.

Aircraft Welding

So vital in keeping aircraft production moving along in large quantities is the subject of aircraft welding, the American Welding Society at its October convention in Cleveland during the National Metal Congress has scheduled at least one or more papers on this subject at every one of its sessions.

(Additional "Trends" on page 842)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trends

By Edwin F. Cone, Editor

More Vanadium

A new method of obtaining vanadium was announced by the American Chemical Society at its 104th meeting in September. The process, described as both economical and rapid, is the result of 4 yrs. of research by Dr. J. P. Morgan, chemical engineer of the Standard Oil Co. of New Jersey, carried out under the direction of Dr. Arthur W. Hixson, professor of chemical engineering at Columbia University. The vanadium exists in high grade phosphate rock deposits in Idaho where there are reported to be 5,700,000,000 tons of the rock of which 500,000 tons are recoverable vanadium i.e. some 0.009 per cent V. In connection with manufacture of fertilizer, the vanadium can be recovered by a special process as vanadium pentoxide.

Should this new source of the metal result in increased supplies, it will be of decided value to the War effort.

Cadmium

Consumption of cadmium in 1941, according to data only recently released, reached 4000 net tons. This is a 31 per cent increase over 1940 when the total was only a little over 3000 tons. About 95 per cent last year went into electroplating, bearing alloys, and pigments.

Malleable Castings

Production of malleable castings to Aug. 1 this year has lagged behind the 1941 rate. Thus far this year the output has been at the rate of 65,269 net tons per month, according to the U. S. Dept. of Commerce. The monthly rate in 1941 was 70,253 tons and in 1940 it was 47,160 tons.

Another Pig Iron Record

The rate of pig iron output by individual blast furnaces continues to advance. A new record has recently been registered by a Bethlehem Steel Co. stack, claimed a world total for one month. Blast furnace H at its Lackawanna plant made 44,659 net tons in August. This is a daily average of 1440 tons. The previous world record is said to have been set by the National Tube Co. in May, this year at 43,866 tons or 1415 tons per day.

Hot-Rolled Alloy Steel

Production of hot-rolled alloy steel products took a big jump in 1941. These are classified by the American Iron and Steel Institute as stainless and alloy other than stainless.

The 1941 output of stainless was 255,090 net tons, an increase of about 67 per cent over the 1940 total of 152,707 tons. Sheets predominated with bars second.

In alloy rolled products other than stainless, the 1941 output was 4,411,355 tons which represents an increase of more than 73 per cent over the 2,543,245 tons made in 1940. Bars constituted nearly 50 per cent of the record in both years, with sheets second.

The 1941 total of both types—4,666,445 tons—was about 73 per cent in excess of the 2,695,852 tons made in 1940.

Sponge Iron

Production of sponge iron bobs up again. Newspaper reports state that the Republic Steel Corp. may erect a sponge iron plant at Youngstown, Ohio, to make 100 tons a day. Probably ore from the company's mines at Port Henry, N. Y., will be used. The sponge iron so produced will probably be used at the company's Canton, Ohio, plants for alloy steel manufacture.

The 1942 Machine Tool Output

Tel Berna, general manager of the National Machine Tool Builders' Association, in a recent address, stated that the industry will build $1,500,000,000 worth of tools this year. This is equal to the production of 10 normal years The output in 1941 was worth $775,000,000 and in 1940 it was $450,000,000.

Silver

Formation of the Silver Users' Emergency Committee has been announced. The aim of the new organization is to "bring silver out of government hoarding vaults and into productive use." Release of some of this silver would ease strictures on the war effort caused by shortages of copper, tin and lead.

Corporation's Earnings

Surveys of first-half earnings of leading corporations tend to dispel any notion that industry generally is making excessive profits on war orders. The *Daily Metal Trade* states that the first-half earnings tabulation of 125 of the largest arms contractors, as compiled by the National City Bank of New York, shows a decline in aggregate net income of 36 per cent below that recorded in the same period in 1941. Compilations made by the National Industrial Conference Board show substantially the same trend—the first-half net income of 333 industrial companies showed a decline of 30 per cent from a like period in 1941.

The 1942 Steel Output

Steel output for the first 8 mos. of this year was 56,952,522 net tons. This is an increase of 4.16 per cent over the same period in 1941 when it was 54,677,224 tons. Apprehension early this year that the 1942 production would be less than in 1941, owing partly to the scrap situation, may turn out to be unjustified.

(Additional "Trends" on page 840)